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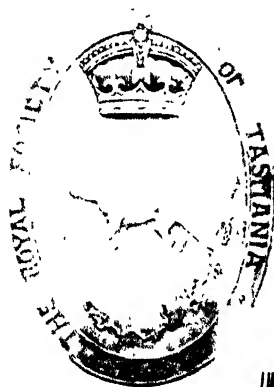




PAPERS AND PROCEEDINGS  
OF  
THE ROYAL SOCIETY  
OF TASMANIA

FOR THE YEAR

vol 73-76 1939-1940



19551  
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PUBLISHED BY THE SOCIETY

The Tasmanian Museum and Art Gallery, Hobart

1940

*Price: Ten Shillings*



# The Royal Society of Tasmania

## Papers and Proceedings, 1939

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## Some Aspects of the Ecology of the Aboriginal Inhabitants of Tasmania and Southern Australia <sup>(1)</sup>

By

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(Read 23rd October, 1939)

### INTRODUCTION

In choosing my subject for this Lecture, I have been influenced by several considerations and it is fitting that they should be briefly indicated. Clive Lord, in memory of whom this Lecture has been established, was essentially a naturalist in the good old sense of the word and as the lives of the Australian and Tasmanian aborigines were so intimately associated with the natural history of their surroundings, such a subject as their reactions to this environment seemed specially appropriate in a Memorial Lecture to him. Under the conditions laid down, the Lecture must deal with some aspect of Tasmanian history or Tasmanian science. Now I cannot claim any special knowledge of Tasmanian natural history or of the records of the Tasmanian natives, but these natives have again assumed a position of very considerable importance in connexion with the present aboriginal inhabitants of the mainland of Australia. Do these latter, or do they not, show any features which may indicate an admixture of Tasmanian blood?

Amongst recent workers, Dr. Wunderly (1938) maintains that there are characters in the present Australian which indicate a Tasmanian admixture. Messrs. Birdsell and Tindale in a recent expedition, organized by Harvard University and the University of Adelaide, with the aid of a grant from the Carnegie Corporation of New York, have been studying the half-caste Australian and Tasmanian populations. Their study necessarily embraced data from Australian full-bloods as well. Their results have not yet been published, but I have been privileged to read the typescript of their proposed first paper in which they bring evidence to show that there is a very definite Tasmanoid element in the Australian native, in those parts of Australia which may be looked on as peripheral regions. One of such peripheral regions is in the Cairns district and another is along the southern coast of Australia. It is highly probable that their conclusions are correct.

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<sup>(1)</sup> Portion of the Clive Lord Memorial Lecture, 1939.

If it is true that there is an admixture of a Tasmanian type in the Australian native, then the study of the ecology of the latter has a very intimate relationship with Tasmania. In the Southern and Central Australian native we may see traits manifested which are derived from their Tasmanian ancestry, and their methods of procuring a living may be in many points similar to those of the recent Tasmanians as of the forerunners of these who dwelt in Australia.

Having had a number of opportunities for studying the natives of the interior of South Australia and of Central Australia in their natural surroundings, I propose to lay before you some of the results and experiences of these expeditions, having in view more particularly how such can be applied to the native inhabitants of Tasmania.

I cannot resist introducing here the description given by La Billardière (*vide* Ling Roth, 1890) in 1792 of his meeting with the inhabitants of Van Diemen's Land to compare it with a recent experience in the Musgrave Ranges of South Australia. So similar was the behaviour of the natives in each instance that one is almost tempted to suggest that it was more than a mere coincidence, such as might happen with any group of indigenes, and that it was based on a natural disposition inherited from a common ancestry. La Billardière had met with a party of natives who then accompanied him for some distance.

'The attentions lavished on us by these savages astonished us. If our path were interrupted by heaps of dry branches, some of them walked before and removed them on either side: they even broke off such as stretched across our way from the trees that had fallen down. We could not walk on the dry grass without slipping every moment; but these good savages, to prevent our falling, took hold of us by the arm and thus supported us. They continued to bestow on us these marks of kindness: nay, they frequently stationed themselves, one on each side, to support us the better.'

A year or so ago, now nearly 150 years after the above incident, Sir Stanton Hicks was engaged in carrying out at Ernabella some physiological observations on Australian natives living under natural conditions in the Musgrave Ranges in the extreme north-west of South Australia. Professor Goldby was with him and, this being the first experience with unsophisticated natives, Sir Stanton was anxious for him to see if possible a corroboree. At dusk one evening, after the day's work, they walked over to the natives' camp and were met by the old men. One of the leaders, anticipating the request they were about to make, asked them if they would like to see one of these ceremonies. Nodding their appreciation of this offer, fire-sticks were quickly got ready and the party moved off in the direction of the ceremonial ground. As the Europeans stumbled along, trying to avoid boulders and fallen branches and the débris that collects at the foot of these mountains, the younger men, most of whom could not speak English, held their fire-brands so as to light the difficult way as far as possible, turned aside the flexible branches in their path and broke off the dry ones, and even moved stones aside. Then in one place, where the light was particularly dim and a boulder lay in the way, Sir Stanton felt something tugging at his feet and discovered that this was a native lifting his leg off the ground to place it in a crevice of the rock to prevent his slipping!

#### HUMAN ECOLOGY

Ecology has been defined as 'that branch of biology dealing with living organisms' habits, modes of life and reactions to their surroundings.' We can

go further, however, and say that the ecology, for instance, of the aboriginal inhabitants of Southern Australia and Tasmania, comprises not only all aspects of *their* reaction to their surroundings but also the reactions of *their* surroundings to *them*.

In studying the ecology of any race of human beings, the following factors will all have to be considered. First, their capacity, mental and physical, to do this and that. Secondly, the nature of the surroundings. In the course of time, a third factor may come in and that is the capacity to meet changes in environment. Man has been singularly successful in his evolutionary ascent for two reasons. First, in his bodily make-up he has never become unduly specialized in any important direction. Secondly, man's brain has so developed that he has in many ways mastered his environment and is now to some extent independent of it.

I do not propose to dwell on the mental and physical capacities of the natives of Tasmania and Australia. The few tools used by the Tasmanians and the primitive nature of these tools indicate that these people were not particularly inventive or ingenious. But then in any European community quite a number of people lack mechanical ingenuity though they may quite readily employ devices invented by others. Moreover such people may possess other mental qualities of a high order. What seems to have been lacking in the Tasmanians who were few in numbers were men of genius outstripping their fellows in inventions which, once discovered, could become common property. One might infer that the Tasmanians did not advance far because the mutations amongst them that produce individuals of superior mental attainments did not unfortunately take the form of mechanical geniuses, at least of mechanical geniuses who could take the occasions presented to them by the hand and lead on to higher things. The Australian, on the other hand, was more inventive with his boomerangs and spear-throwers, and there is no doubt, from his large vocabularies, the construction of his language, his mythology, his explanations of natural phenomena and so on, that he possessed a mental make-up of quite a high order. Obviously intermixture of races should facilitate the variety of advantageous mutations that might be expected, for each race will tend to vary along its own particular lines and with the intermixture all these are pooled. Once a discovery is made, many can use it who could not have invented it. Perhaps one reason why the present day Australian native seems to have been superior to the Tasmanian is, as seems now probable according to Birdsall and Tindale, that he is a mixture of Tasmanian with two or perhaps three other strains as well. The Tasmanians and Australians were clearly physically capable of doing all that Europeans can do, as witness the excellent work done by those who came under white influence. The mental make-up of the Tasmanians probably was deficient in mutations useful to them in their surroundings, but it was in some directions, such as observations in natural history and tracking, of a high order.

Discussion of the second factor, the nature of their surroundings, will occupy most of what I have to say. It may be as well, however, here to dispose of the third factor, the capacity to change with changing environment. The appearance of a hostile race is a factor of supreme importance in this connexion. The autochthones may have to fight these, or may amalgamate with them to a greater or less extent, or may get driven into less desirable regions where conditions are more difficult and fresh experience has to be gained. The Tasmanians probably were driven before the invaders, amalgamating with them to some extent, probably through captured women, along the lines of junction. Those that reached Tasmania were relatively secure. Still another aspect has to be considered. The



blood groups found, only A and O, indicate that the Australian native must have occupied this continent for a very long period of time. It is probable that, during this, great changes in the vegetation have occurred and that a richer fauna and flora were present in the interior of Australia in these early days. Man may have had to modify his activities in many ways as the difficulties in securing food increased with increasing aridity. His existence to-day shows that he overcame these difficulties successfully.

#### THE ENVIRONMENT IN WHICH THE NATIVE INHABITANTS OF AUSTRALIA AND TASMANIA FOUND THEMSELVES

The first and most important ecological factors for all races of mankind are necessarily food and water. Under primitive conditions, when much time must be consumed in procuring the necessary food, other aspects of the ecology sink into comparative insignificance. It is only later in man's development that geographical features, apart from food supply, play a prominent part as in trade. It thus comes about that our chief subject under this heading deals with the food available to these people and the means they adopted to secure it when it was difficult to come by.

J. W. Bews (1935) has classified mankind in somewhat ascending order into the Food Gatherers, the Plant Cultivators, and the Herdsmen and Pastoral Nomads before we come to the differential activities of highly civilized man. Both the Tasmanians and the Australians belong to the first and most primitive category, that of the Food Gatherers, without any evidence at all of any tendency to pass into the more evolved types. Is their position on the lowest rungs of the human evolutionary ladder purely the result of their mental capacity not having as yet progressed sufficiently far for them to have reached a higher stage, or is this failure to develop in part at least due to the environment in which they found themselves?

Now the mainland of Australia and Tasmania are singularly devoid of edible plants that might lend themselves to plant cultivation, and of animals that could be domesticated so as to develop a race of Herdsmen and Pastoral Nomads.

Though European settlement has now been in existence in Australia for over 150 years, not a single species of plant, with one or two trifling exceptions, has been taken into cultivation as a food plant. Turning to animal sources of food, there is no mammal that could be a source of milk, and the natural pastures would be a much more suitable field for the multiplication of kangaroos and wallabies than any process of domestication and control could be. In other words, the Tasmanian and Australian natives reached a land that gave them no opportunity whatever to practise the arts of plant cultivation or of animal husbandry, even had they possessed a knowledge of such before their arrival.

We are, therefore, in the position to say that, when man reached Australia in those far-off days, he reached a land highly unsuited for the development *ab initio* of a race of Plant Cultivators or one of Herdsmen and Pastoral Nomads, and equally unsuitable for the continuance of such practices had they been acquired elsewhere, unless he had brought with him the necessary plant seeds or roots and the appropriate domestic animals.

Moreover, when they did arrive in the northern coasts of Australia, as castaways or as coastal voyagers, or by a now submerged land bridge, whatever may have been their former status they became Food Gatherers as soon as the

small supply of food they brought with them became exhausted. On such an inhospitable coast, all their energies would be necessarily directed to an incessant daily search for something to eat. Local supplies being soon exhausted, they had to move further afield and no time could have been spared to stay in one place and await the growth of any seed they had planted.

Thus Food and Water at once became the primary factors in their Ecology. All else sank, temporarily at least, into insignificance. Let us first consider their environment from this point of view.

### Foods

Ling Roth (1890) and Brough Smyth (1878) give full accounts of the known and possible foods of the Tasmanian natives, whilst many have written on those of the Australians. Time does not permit me to consider these in any detail. I shall merely give a few examples where the collecting of food has unusual ecological relationships or where its preparation may have values which at first sight might pass unnoticed.

*Grains.* Of the fifty species of Tasmanian grasses given by Leonard Rodway (1903) not a single one of them would be likely to yield grain that could be collected in any quantity, winnowed and ground for food. The same remarks apply to the temperate southern parts of Australia and probably to its eastern coast. These are not the regions for grain production. If the Tasmanians during their wanderings had become acquainted with the use of these grains—and doubtless they had, in parts of Australia—such knowledge was of no further use to them in Tasmania. On the other hand, grasses, differing almost entirely specifically from those in the southern parts, are abundant in the drier interior and some of these, such as several species of panic-grasses, yield a suitable seed.

The grains from grasses and the minute seeds obtained from such plants as species of *Chenopodium* are collected in various ways. Some, such as the seeds of *Portulaca oleracea*, (the munyeroo), are obtained by pulling up the plants and placing them on a rock surface when the upper part of the capsules come apart, setting free the minute black seeds which then can be swept together and transferred to a coolamon for winnowing. The grass seeds may be gathered by hand, but at Macdonald Downs in Central Australia, we were witnesses of a very interesting method of collecting. The panic-grass had been growing on an extensive flat after the summer rains; the grass had become much dried up and beaten down. The grass seeds, however, had been collected together by small black ants and arranged in heaps round the entrances to their nests. To these the native women immediately made their way and filled their coolamons or dishes in a very short time with a mixture of grain, chaff, sand, dust and debris. A hole about one foot in depth was dug with a digging stick in the ground at the base of a mulga tree. Into this the contents of the coolamon were thrown and the native woman then stepped in and de-husked the grain by twisting and turning with her feet, meanwhile supporting herself in part by holding on to the mulga tree (Plate I, fig. 2). This, of course, added much more dirt to the mixture which was now taken out and rocked in the coolamon up and down and to and fro, handfulls being taken up from time to time and let drop, blowing away some of the chaff and dust. By means of these interesting and complicated movements the grain was rapidly separated from the chaff and sand and foreign particles so that, aided by skilful movements of the hand, a sufficiency of grain was soon collected fit for grinding. The grinding was done between two stones, the upper one held in the hand and the grain being in a groove in the larger lower one. A little water

was added as the grinding proceeded. The paste, when ready, was poured into a space in the hot ashes. Several glowing sticks were now suspended over the upper surface of the damper, these being so laid as to form by their heat a protective film on the surface. As soon as this was sufficiently firm the ashes were heaped over so as to cover the damper completely.

One of the most interesting ecological associations was witnessed by Dr. Hackett and Mr. Tindale south of the Musgrave Ranges. Desert currajong seeds were collected by the natives in numbers around the rock holes in the Ranges. The desert currajong (*Brachychiton Gregorii*) grows well out in the sandy country to the south. Crows feed readily on the softer tissue surrounding the seeds, swallowing the seeds as well. The crows make back to watering places and there discharge the seeds in sufficient abundance for them to be collected by the natives and ground between stones to form a meal. One is reminded strikingly of Elijah being fed by the ravens.

*Animal Foods.* Time does not permit of considering in any detail the animal foods used or the methods employed in obtaining them, important though they be in their ecological relationships. Mammals and birds and birds' eggs formed a most important part of the food of both races. The natives of the Warburton Ranges in Western Australia, when a large kangaroo has to be carried on the head any distance, make a small incision in the abdomen with a sharp stone, take out some coils of intestine, skewer up the opening with a piece of stick, and then truss up the carcass with its limbs and tail into a compact burden using as thongs the intestines after rolling them in the dust. The hair is singed off and the carcass partly buried in and partly covered by hot ashes. In this way all the natural juices with their containing salts are retained and much relished. Such a carcass is rapidly cut up with a stone implement fastened by a gummy substance to the end of a spear-thrower. Each person has his allotted share, depending on tribal relationships. The bones are smashed open and the marrow and pounded bone eaten, the latter helping to maintain the supply of phosphates and calcium.

The Tasmanians, for some unknown reason, did not eat fish, but used shell-fish. The Australians utilized every possible source of animal food. The Tasmanians relished the large white grubs found in dead and dying trees and the eggs of large ants. These large grubs, the larvæ of beetles or moths, known as 'witchitty' grubs or 'bardi' amongst the Australians, were equally relished by the latter. In addition the mainland natives ate lerp scales, coccid secretions from the mulga ('mulga sugar'), large female coccids (*Apiomorpha*?) in apple-sized galls on eucalypts, termites at the time of swarming, the honey of the honey-ant and other insects and insect products.

*Honey.* Sweet substances must have been lacking in the diet of both the Tasmanians and the Australians. Various plants, such as Hakeas, Banksias and Grevilleas, often yield abundant honey when the racemes of flowers are drawn through the mouth. The blossoms of Eremophilas may be sucked. Fibre from the Liliaceous *Dianella revoluta* may be rolled up in the hand and then drawn up over the honeyed flowers of the Grass-tree (*Xanthorrhoea*), the honey adhering to the fibres. The Australian native bees are stingless and native honeycomb is a great delicacy to the natives of Central Australia. At MacDonald Downs we were shown the method, which proved unusually interesting, of detecting the presence nearby of a native bees' nest. When we had reached a likely locality the natives, instead of looking up in the trees to see the bees possibly entering or departing, got down on their knees and began searching minutely amongst

the sand and particles on the relatively bare earth (Plate I, fig. 1). Soon they were rewarded by finding several very minute, dark particles which had been carried away by the bees from the proximity of their nest and dropped. As it was now certain that there was a bees' nest in the neighbourhood, likely trees were tapped to see if they were hollow and, if necessary, these were climbed, until finally the one harbouring the comb was discovered. After chopping open the hollow a piece of bark was knocked off a neighbouring projection on the tree to form a receptacle into which the honeycomb and entangled bees were placed by the native before he descended. According to tribal custom all those present shared equally in the repast.

The bees that supply honey in any quantity sufficient to be an article of food for man belong to the family Apidae, embracing the Social Bees or Honey Bees. Tillyard (1926) states that all the nine Australian species of this family belong to the genus *Trigona*, very small bees devoid of stings. These bees build in hollows of trees. Rayment adds a single species of the genus *Apis* (*A. aenigmatica*) found by him in Gippsland, which built three tiny combs the size of the palm of one's hand in the open on a verandah. The honey supplies of the Australian natives were obtained from species of *Trigona*. Round Brisbane, Hockings (1884) gives the native name for *T. Cassiae* Ckll. as 'kootchar' and that for *T. carbonaria* Smith as 'keelar' or 'karbi'. Tillyard says that the commonest species *T. carbonaria* is found 'almost everywhere' (i.e. in Australia), but Rayment says our species of the genus are confined to the warm north, *T. carbonaria* being found as far south as Sydney. Ling Roth (1890) does not mention honey as one of the foods used by the natives of Tasmania, but Brough Smyth (1878) says 'they climbed trees . . . to procure honey, the women carrying with them grass baskets in which they placed their spoil.' The honey-bee, *Apis mellifera* L., was introduced into Australia in 1822 and probably was taken to Tasmania not much later. Brough Smyth's reference therefore possibly may apply to this introduction, though one could hardly imagine an unprotected native attempting to rob the nest of this bee. If a native bee, to what genus does it belong? According to Rayment, it should not be a species of *Trigona*. Is it another species of *Apis*? Are specimens of the bees and their comb available?

The species we met with in Central Australia was almost certainly a *Trigona*. What is the nature of the small particles left by the bees at a distance of many yards from the site of their comb and searched for on the ground by the natives? These are about 1 mm. in size, irregularly spherical with a mulberry-like surface and very dark, almost black, in colour. I have five of these but do not like to sacrifice any for a possible identification by chemical analysis. Their appearance suggests that they may be resinous. Mr. Womersley thinks it likely that they are particles of propolis, the cement-material used by the bees. But this is valuable and is not likely to be carried away to some distance from the nest. The workers of *Trigona* are small bees only 4 to 6 mm. long, so their individual excreta could hardly be in diameter a quarter to a sixth of their length. However, Rayment (1935) says there is always a busy traffic from the nest carrying out round, flat cakes of brown excrement, which is held by the mandibles and tucked in well under the head. Perhaps the material is a mass of excreta cemented together by propolis.

**Water.** Water for drinking is, obviously, an essential in the ecological surroundings of man. Man, however, differs from other animals in that, through his mental equipment and ingenuity, he can overcome an environment unfavourable to him in this respect and carry water with him in natural or artificial receptacles.

He may also obtain water from unexpected sources or conserve the supply he has already imbibed.

The Tasmanian native can rarely have felt the lack of water for drinking purposes in Tasmania. As his ancestors probably had inhabited the drier parts of Australia, it is of interest to consider the ways devised by the Australian aborigines for supplementing their supplies of water. Neither the Tasmanian nor the Australian possessed receptacles capable of transporting water over long distances. The Tasmanian made use of the bladders of *Fucus*, or utilized shells, bark, and skulls as receptacles for carrying water to the place of eating. The Australian uses wooden pitchis for a similar purpose, frequently sprinkling a few leaves on the top to lessen the liability to spill. Baler shells are used along the northern coasts. In the drier parts of Australia, the question of a water supply may often far outweigh the importance of food, though the two react on each other. The native can only search for food within a reasonable distance of water. Food supplies are soon exhausted in any locality, and the nomad must then make for another place where water is to be found, where the process is repeated. During the course of a year, a regular round of watering places with their supplies of food are visited, all within the tribal area. In times of drought, water may become scarce, and any possible temporary substitute may have to be employed. Spencer and Gillen (1912) describe the frog *Chevroleptes platycephalus* and three other species, as swelling up with imbibed water after rains. Then when the rains are over, they aestivate in a chamber in the mud. Such buried frogs the natives can locate, and by compressing the urinary bladder can obtain water which is quite fresh and pure. The Needle Bush (*Hakea leucoptera*) is extensively distributed in the north of South Australia. It has long roots running superficially which can be readily exposed and pulled up. If cut across in short lengths and stood upright in a pitchi, water will drip out of the pores in drinkable amounts.

In the drier mallee areas of Southern Australia an abundant supply of excellent water can be obtained from several species of these eucalypts. Travelling north from Ooldea over a stretch of a hundred miles without any surface waters, the natives successfully cross this dry stage by relying on this source. Water in various quantities can be obtained from the superficially radiating roots of a number of eucalypts even in areas such as Encounter Bay in South Australia where the rainfall is over 20 inches. We have seen it obtained in most quantity from *Eucalyptus transcontinentalis*, perhaps only a variety of *Eucalyptus oleosa*. Radiating from the butt for 30 or 40 feet or more are rounded roots up to an inch or more in diameter. These, near the butt at least, have no rootlets and run an almost straight course outwards. They are only an inch or so below the surface of the more or less sandy soil and can be readily pulled up in lengths of many feet. They are relatively brittle and on examination consist almost entirely within the layer of bark of closely set tubes just visible to the naked eye. Broken into lengths and held vertically aloft over the mouth or on end in a receptacle, water drips freely, sometimes almost in a stream, whilst by blowing at the upper end it gushes and bubbles forth from below. Evidently by its distant ramifications and terminal rootlets, moisture in the sandy soil from even the slightest rain and perhaps from dew fallen from surrounding shrubs is retrieved and passed into the tubes in the bigger roots.

Mr. H. A. Dadswell, of the Division of Forests Products, C.S.I.R., Melbourne, has kindly examined for me specimens of water-bearing roots from *Eucalyptus transcontinentalis* and *Hakea leucoptera* from Ooldea and from *E. fasciculosa* from

Encounter Bay. Cross sections of each were prepared for microscopic examination, and, after making measurements over the whole area of the root, the average percentage available pore area per sq. mm. of area was determined. For *E. transcontinentalis*, a small root 5.5 mm. in diameter gave an average of 32.3 per cent (Plate II), a medium-sized root of 22 mm. 31.6 per cent, and a large root of 27 mm. 33.5 per cent. A root of *H. leucoptera* 15 mm. in diameter gave an average of 34.5 per cent, and one of *E. fasciculosu* 13 mm. in diameter 27.2 per cent.

In discussing these results he writes: 'If we take the medium-sized root of *E. transcontinentalis* and assume that a length of 100 cm. was available, then the available free vessel space (neglecting the small central area) would be able to hold approximately 120 c.c. of liquid'. Thus a root a little less than an inch in diameter and a little more than a yard long could hold about 4 ozs. of liquid. Again a root 30 feet long and an inch in diameter could hold about 94 cubic inches of water. Thus about 3 of these roots could supply a gallon of water if all the fluid could be expelled. This however would not be the case on account of capillary attraction.

Magarey (1895) has given a full account of the sources of water available to the Australian native and of the indications of the likelihood of the presence of surface waters. The sources include rock-holes, soaks, natural hollows in trees, succulent plants and dew collected sometimes by a sponge-like handful of fibre. Open rock holes may be protected from evaporation or contamination by coverings. Certain birds are a sure indication of the proximity of water as are the natives themselves, though in this case the supply may not necessarily be an open one.

#### Adornment of the Person

Adornment of the person is an essentially human trait. It may take the shape of mutilations, dressing of the hair, clothing apart from, or in addition to, its protective qualities, the use of necklaces, rings and flowers, and the employment of pigments, including tattooing and fats. As examples of mutilations may be mentioned cheloid scars, amputating a digit and cutting the hair or shaving it off or epilating it. The knocking out of one or more teeth probably had, like circumcision and subincision, a deeper significance, though this may have been lost in some cases as in the Musgrave Ranges in South Australia.

I am not aware of any records of other mammals or birds adorning themselves under natural conditions. However, Professor Agar has kindly given me a reference to a most interesting account given by Köhler (1925). He describes how his chimpanzees were fond of hanging ropes, twigs, rags, &c., over their necks, shoulders or ears. He says 'No observer can escape the impression that . . . the objects hanging about the body serve the function of *adornment* in the widest sense. The trotting-about of the apes with objects hanging round them . . . seems to give them a naïve pleasure. Naturally we can scarcely assume that apes have a visual image of what they look like when dressed up like this, and I have never observed their frequent use of reflecting surfaces as in any way connected with their adornment; but it is very likely that primitive adornment like this takes no account of external effect—I do not give the chimpanzees credit for that—but is based entirely on the extraordinary *heightened bodily consciousness of the animal*'.

The natives of Tasmania and of Australia took pains to produce cheloid scars by making incisions which were kept open until granulation tissue had been produced from which the dense scar tissue was derived. The hair of the

Australian sometimes appears as ringlets plastered with grease and mud or may be arranged in a chignon or bun around an artificial core (Plate I, fig. 4). The Tasmanians, according to J. B. Walker (1914, p. 238), wore necklaces of shells strung on twisted kangaroo sinews dyed with red ochre; by treating the shells by burning grass over wood embers, thus producing pyroligneous acid (acetic acid), their outer coverings were removed exposing a surface that yielded prismatic colours. The Australian native uses hair-string, made from human, wallaby, wombat and other sources for various purposes and often as a band around the forehead under which the flowers of *Cassias* and other plants may be tucked. Girls and young women may insert the tips of slender locks of hair into the capsules or buds of *Eucalypts* giving quite a picturesque appearance as they dangle (Plate I, fig. 3).

Péron (1809, p. 196) gives a graphic account of his meeting with a group of Tasmanian women. These 'with the exception of some few who had the skin of a kangaroo over their shoulders, were all entirely naked . . . Their black skin disgustingly greased with the fat of the sea-wolf, their short woolly hair, which was black and dirty, and which some of them had powdered with red ochre; their figure besmeared with the dust of charcoal; their shape generally lean and shrivelled . . . in a word, all the particulars of their natural constitution were in the highest degree disgusting'.

Red ochre, yellow ochre and white earthy pigments are extensively employed amongst the Australian natives, either in the shape of definite designs or sometimes applied indiscriminately. Charcoal also may be used, as it was by the Tasmanians. In the central parts of Australia there is to be found a stalked puff-ball, *Podaxon pistillaris*, the stalk of which is surmounted by a fusiform fruiting body. The exoperidium can readily be removed from this like a glove from the finger, leaving behind a dark purplish-fuscon mass of spores. Holding the base of the stalk in his hand the native may apply this purplish mass liberally to the cheeks and nose much as face powder is employed by Europeans; in both cases a 'flesh-coloured' tint is applied.

The down of birds lends itself to decorative purposes, especially that of the eagle. It is extensively used for ceremonial purposes being stuck on to the body by means of the sticky serum that exudes from the clotting of human blood. To obtain this blood, the men readily open the veins of the arm by means of a short longitudinal incision with a sharp pointed piece of stone, often prepared on the spot. Recently at Ooldea some of the younger men were wearing long feathers, such as those of the bustard or native turkey, tucked into the hair arranged as a chignon. These plumes waving about had quite a picturesque effect. Other instances of adornment consist of placing sticks through a perforation in the septum of the nose (Plate I, fig. 4), and often flowers may be inserted in this way.

#### Adhesive Substances

Adhesive substances are of very obvious importance to primitive peoples. Their non-use may mean either that their practical applications have not been realized or that the requisite materials are not available. The sticky serum from clotted blood is mentioned elsewhere as being used for applying eagle down to the surface of the body or to materials used for ceremonial purposes. The adhesive substances, however, which chiefly concern us are those employed in making or hafting weapons and tools. In the central parts of Australia various gummy and resinous substances are in general employment for fixing stone flakes at, for instance, one end of a spear-thrower to form a small adze, or for the

purpose of helping to fix an axe head on a cleft stick, or to support wallaby tendons in attaching the spear point to the end of a long light shaft, and for other similar purposes. One of the best and most abundant sources of this kind of substance is a species of porcupine grass (*Triodia*), the plant referred to by explorers usually as 'spinifex'. Most of the *Triodias* have a resinous material between and around the bases of the leaves. This is, in some species, so sticky that occasionally birds may lose feathers from coming in contact with it. It also gives rise to a fierce flame when the porcupine grass is burnt. Considerable quantities can be collected by the natives and made into flat cakes of a dark colour. These can be readily melted and soon set firmly again.

On the Diamantina we were surprised to find that mindry gum was obtained from the roots of *Leschenaultia divaricata*, one of the Goodeniaceae. Gum from *Myoporum platycarpum* (False Sandalwood) and from grass-trees (*Xanthorrhoea*) are also employed in more southern parts, but these materials seem more brittle and less useful. There seems no evidence of the employment of such adhesive substances by the Tasmanian natives. This is probably due to the absence of suitable material. Though grass-tree gum is used on the mainland, it does not seem very successful, and its use there may have been merely an attempt at copying the more successful gum substances of the interior. I cannot recall any other vegetable product in Tasmania that would be likely to lend itself for this purpose.

#### THE NATIVE'S CONTROL OF HIS ENVIRONMENT

A little consideration will show that the natives of Tasmania and Australia exercised but little influence over their environment, whilst more advanced races controlled their surroundings by clearing forest lands and planting crops, by growing fruit-trees and vegetables and domesticating useful animals. In great part our natives, through no fault of their own, did none of these. Though the control of their food supply by cultivation was negligible and the breeding of useful animals non-existent, they were nevertheless under the firm conviction that by increase ceremonies and tabus they were actually in control of these supplies and able to affect their abundance.

#### Control of Temperature

The most interesting aspect of his control of his environment is, however, seen in the ways he overcame the effects of low temperatures and secured for himself a sufficiency of warmth in cold weather. We therefore have to consider his control of the temperature to serve his ends or even to make continued existence possible.

Climate is naturally one of the most important ecological agents affecting man, as also other animals and plants. When in the course of evolution, various vertebrates emerged from the waters in which their ancestors had developed, they overcame the difficulty in change of environment by devices which really meant that they carried their essential original surroundings with them. With the coming of warm-blooded creatures, mammals and birds, a suitable temperature was maintained throughout with consequent better control over the environment. Feathers or a hairy covering conserved heat during cold periods. Man's natural covering of hair is so poor, however, that it can serve him but little as a protection against cold. The utilisation of the skins of animals for purposes of warmth was a discovery of much moment to him. Nevertheless as a nomad such an added burden of weight might at times be a handicap. The making of breakwinds and shelters doubtless preceded the making of garments. Finally came the discovery of fire



as a means of warmth and later for cooking. Shelters, clothing and fire enabled primitive man to extend his range to colder regions—by means of these devices the environment was controlled so as not to be injurious to him. How did the Tasmanian and Australian natives fare in this regard? No clothing of any kind is worn by the natives—men, women and children—in Central Australia. In the more southern parts and in Tasmania, the skins of animals were sometimes used, but the amount of warmth thus obtained cannot have been great, and in the case of the Tasmanian women it is considered that the skins were chiefly used to support the infants. Fire has been the chief means for mitigating the effects of cold. The native of Australia invariably carries a firestick with him, which in cold weather gives a little warmth, waved in front of his body and with which he may frequently set fire to tussocks of porcupine grass and bushes and warm himself at the blaze. At night he sleeps behind a breakwind with a little fire on each side of him and often another at his feet. Sir Stanton Hicks and W. J. O'Connor (1938) have carried out a number of investigations on the heat regulation of the Australian natives under cold conditions. They find that, as a result of the use of these small fires, to which the native is able to lie very close, areas of high skin temperatures are to be found on the body of the sleeping native. They believe that in this way a considerable amount of radiant heat is absorbed, which counter-balances to some extent the loss from those parts intensely cold. Moreover the aboriginal has an extremely active control over the blood circulation in his skin so that heat loss from a cold part is minimized by a diminution of circulation through that part. In contrast with the clothed European, whose metabolism is increased when he is cold, so that more fuel is used to warm him, the native does not show any such increase. Where food supplies may be precarious, this conservation is an interesting finding, there being no needless waste of food income merely for the purposes of warmth. Thus the chief means adopted for maintaining the body warmth during cold weather and especially at night consist of breakwinds, small fires yielding considerable radiant energy, and such a local control over the blood circulating in the skin that those parts exposed to the cold lose as little heat as possible through a diminished circulation through them.

## THE EFFECTS OF HIS EXTERNAL ENVIRONMENT ON MAN

### Teeth

*Absence of Caries.* The infrequency of caries of the teeth in Tasmanian (Wunderly, 1939, p. 331) and Australian (Campbell, 1939) natives is well known and at once obvious on examining any collection of skulls. Campbell has fully dealt with the Australian aspect. Decalcification of the enamel apparently can only be achieved by the action of acid. A sticky, fermentable carbohydrate glued on to the teeth may there undergo an acid fermentation and the concentration of acid may be sufficiently great to lead to decalcification; in this way decay originates. Living under natural Australian and Tasmanian conditions glutinous food-stuffs are negligible in amount, and even where grains are ground the resulting flour is so coarse that the food does not tend to become adherent around the teeth. The fibrous, stringy and tough nature of much of the food also exercises a detergent effect, reducing again the risk of caries.

*Attrition,* or grinding down of the teeth, is a striking feature in Australian and Tasmanian skulls. Sometimes by middle life the teeth are so ground down as to be on the level with the gums, the pulp chamber having been obliterated by the formation of secondary dentine as the attrition proceeded. This grinding

away of the teeth is attributable to the incorporation of much sand and grit in food-stuffs consumed in the open and to the separation of small stone particles in grinding grain in the hand mills. In addition much masticatory effort is required in dealing with foods which are often tough and fibrous. F. St. J. Steadman (1937), in a recent examination of 52 Tasmanian skulls in collections in England, states that a very striking feature was the marked and almost universal attrition. Dr. W. Crowther has kindly supplied me with notes on the degree of attrition in Tasmanian skulls in his own possession and in the Tasmanian Museum. He finds that this condition is frequent, though the degree, perhaps, is not so great as in some Australian skulls.

### Intoxicating Beverages and Narcotics

These might be considered under the caption of food, but they seem more appropriate when considering the effects of his external environment on man. The Tasmanian natives obtained a fermented drink from the saccharine sap which exudes at certain seasons from the Ribbony or Cider gum. Holes were ground into the trunk, and the juice that flowed from the apertures was collected in a hole at the foot of the tree and allowed to ferment.

On the mainland of Australia, two Solanaceous genera of plants, *Nicotiana* and *Duboisia*, include species with narcotic properties, used by the natives. Neither genus occurs in Tasmania, and in fact there are there only two species altogether of this family, namely *Solanum aviculare* and *Solanum nigrum*. The Tasmanian aborigines had therefore no chance of using narcotics, though this Society has an interesting association with the famous pituri or pitcherry of Australia. Morris (1898) gives the earliest reference to the employment of the word pitcherry as being in the Proceedings of this Society for April, 1863, p. 1, when W. Johnston presented nardoo 'seed' and pitcherry. The wording is "Pitcherry", a narcotic plant brought by King, the explorer, from the interior of Australia, where it is used by the natives to produce intoxication . . . In appearance it resembled the stem and leaves of a small plant partly rubbed into a coarse powder . . . On one occasion, Mr. King swallowed a small pinch of the powder, and described its effects as being almost identical with those produced by a large quantity of spirits.'

Morris was, however, not correct in his statement that the first printed use of the word 'pitcherry' was in these Proceedings as Wills in his diary, dated May 7, 1861, referred to 'bedgery or pedgery' (other spellings for pitcherry) and this diary was published in 1861 and again in 1862 and 1863. Pituri (this seems to be the most appropriate spelling) consists of the twigs and dried leaves of *Duboisia Hopwoodii* gathered somewhere in the neighbourhood of the upper parts of the Mulligan River near the South-west corner of Queensland. It was traded extensively to the natives along the Diamantina and thence even down to the Flinders Ranges and eastwards along the Cooper (Johnston and Cleland, 1933-34). Coming from afar by barter to these southern tribes, it had a glamour about it which helped doubtless to mask its origin. Bushes of *Duboisia* grow at Bellamy's Well, about 70 miles west of Lake Torrens, and yet this nearer source for the leaves and twigs was not realised by the natives of the district or those of the Flinders Ranges. Moreover the plant grows abundantly in the sandhill country of Central Australia, where it is used for stupefying emus by placing small quantities in the rockholes where they come to drink. In these parts it is not used at all by man or at most only occasionally when another narcotic supply, the leaves of several species of true tobacco (*Nicotiana* spp.), are running short or

not available. This latter source is of unusual interest. With the possible exception of New Guinea, America and Australia are the only parts of the world where species of *Nicotiana* are indigenous. In both regions, the native inhabitants have discovered their narcotic effects and prize them highly in consequence. Fifteen species have already been described from Australia (Wheeler, 1935). Of these we have personally observed the use of four (*Nicotiana excelsior*, *N. Gossei*, *N. ingulba*, and *N. Benthamiana*), whilst other species, often similar in general appearance, are discarded. Their employment for chewing extends at least from the Musgrave Ranges (south of 26° Lat.) in the N.W. of South Australia to the whole extent of the MacDonnell Ranges and as far north as the Granites in the extreme west of the Northern Territory near the parallel of 20.6° Lat. The leaves, fresh or dried, are chewed into a bolus which is parked when not in use behind the ear where it is readily available for personal use or that of a friend. From time to time it is rubbed in the fine wood ashes obtained by burning small twigs of several species of *Acacia*, especially *A. ligulata*, the alkaline ash accentuating the liberation of the alkaloid nicotine. Chewing is the only method the natives employ in using it though European tobacco may be smoked in a pipe or cigarette or chewed. The pre-European American Indians apparently smoked their tobacco in pipes or as cigars, inhaled it as snuff and chewed it as well. There can be no doubt that the use of indigenous species of *Nicotiana* by the Australian natives antedated any European influence.

#### CHANGES WROUGHT IN THE ENVIRONMENT THROUGH THE AGENCY OF MAN

##### Destructive Wood-Infesting Grubs Eaten by Natives

Civilized man has made remarkable and, in some cases, lamentable, changes in his environment. What changes in their environment can we attribute to the natives of Tasmania and Australia?

For the purposes of this discussion we can consider them together, and our analysis will show that these food-gatherers exercised extraordinarily little permanent effect on their surroundings. There was no tilling of the soil and consequently no clearing of the original vegetation of the land. With the exception of the dingo kept by the Australian native, there were no domesticated animals at all, and so no flocks and herds to play their part in altering the country-side. The nomadic character of the Australian aborigine did not lend itself to the serious depletion of the vegetable and animal foods on which these people depended, so that a balanced position was attained. We have no reason to think that any species of animal or plant disappeared as a result of its use as food by the natives.

They did, however, exercise some control by extracting the large white witchetty or bardi grubs of certain beetles and moths found in the stems and roots of a number of native trees and shrubs. Since the introduction of the rabbit the Australian native has been playing quite an important role in its control.

##### Effects of Fire

Both the Tasmanian and the Australian natives were able to make fire and habitually used it. The Australian and Tasmanian vegetation is remarkably resistant to exposure to fire. Many shrubs and trees sprout again, and the effect of these fires is to produce a very considerable seed-bed. Is there any evidence that this recovery from fire is a result of the evolution of fire-

resistant types of plants? Information supplied to me by the Conservator of Forests in South Australia, Mr. G. J. Rodger, shows that forest fires from lightning may occur not infrequently. Before the coming of man, however, such fires, occurring only after long intervals, probably exercised little influence on the vegetation. When man came, however, accompanied in his wanderings by fire, which he either carried with him or made by the 'sawing method' or the 'twirling method' as occasion demanded, accidental fires were probably frequent, though a recent writer in 'Nature' doubts whether this was the case. It is quite possible that the frequent occurrence of fires has led to the disappearance of some species of plants, perhaps numerically few, which were unusually susceptible to it. We have, of course, no means of ascertaining how many kinds of plants have disappeared in this way. Any alteration in the appearance of the vegetation from this cause is as nothing compared with the effects of clearing the land and grazing produced by Europeans. In Tasmania, however, James B. Walker (1914) describes open plains formerly known as favourite resorts of the blacks which subsequently became overgrown with forest during the discontinuance of their annual burnings. Dr. D. A. Herbert (1938) suggests that certain grassy areas interspersed with rain forest in the Bunya Mountains in Queensland were the result of fires produced by the blacks. Taking them altogether it will be seen that the changes wrought in the environment through the agency of primitive man in Australia and Tasmania are almost negligible.

## THE EFFECTS OF THE ENVIRONMENT MAN BROUGHT WITH HIM TO AUSTRALIA

### Parasites and Disease

In considering the ecology of man, one must not overlook that intimate environment that he himself carries with him, an environment in which parasitic and saprophytic organisms may flourish and the former be responsible for disease. The parasitic organisms themselves may possess a relatively simple life-history associated almost entirely with man, as in the case of head-lice and such viruses as those of poliomyelitis and epidemic influenza; or the life cycle may be a complicated one, involving intermediate hosts, which in their turn may be dependent on specialized conditions as in malaria and yellow fever, sleeping sickness and hydatid disease. It is unnecessary to dwell on the toll on human life that some of these diseases may take. What part have such organisms played in the lives of the Australian and Tasmanian natives in the pre-European era?

Early vocabularies, both Australian (Brough Smyth, 1878) and Tasmanian (Ling Roth, 1890), give native words for the louse, presumably the head louse of man. These early references indicate that these creatures accompanied both races when they reached Australia. We can say definitely that the Australian native was not the host for any helminth (worm) parasites before contact with Europeans. Both the Australian and Tasmanian natives readily acquired European infective diseases when exposed to them, and many died in consequence. The scattered nature of the population and the infrequent intercourse between tribes led, however, to the almost complete absence of epidemic and infectious diseases amongst the original inhabitants; whatever they may have brought with them, with one or two possible exceptions, died out in consequence of these difficulties.

It is doubtful whether they suffered from infectious colds, and they certainly did not suffer from tuberculosis, measles and other similar diseases before the coming of the white man.

Nevertheless they did suffer from two important diseases. In 1789, a little more than a year after the First Fleet reached Port Jackson, natives were found dying in considerable numbers in rock shelters and other situations round the Harbour from an eruptive disease which was considered to be smallpox. Brough Smyth (1878), in a statement to which, perhaps, little credence can be attached, says that it is conjectured that prior to the colonization of Tasmania a large number of persons had been carried off by smallpox. Smallpox amongst the Australian natives swept across Australia in three waves of which there are records (Cleland, 1928). Apparently it had been introduced on each occasion along the northern coastline, probably by Malay trepang fishers.

The other disease is yaws, which Dr. C. Hackett (1938) has shown to be widely spread in Central and Northern Australia and probably occurred throughout it. It is possible, though not probable, that certain references to skin conditions in the Tasmanians may have been to yaws. The infection of yaws is spread by accidental contact, direct or indirect, from open sores in which the spirochaetes may be abundant. The native is unclothed, so that all sores are exposed freely to the air, and anyone who has paid a visit to the warmer parts of Australia in summertime knows how abundant flies are and how they cluster round the eyes and mouth and especially round any sore with a moist surface. Quite obviously flies are a ready means of transmitting the infection from one case to another, and flies consequently have played quite an important role in the ecology of the Australian native, and possibly also in the Tasmanian.

Captain Dampier (1697, p. 282), writing of the natives of the North-west of Australia, described them as being the 'miserablest people in the world. The Hodmadods of Monomatapa, though a nasty people, yet for wealth are gentlemen to these.' In describing their appearance he goes on to say that 'their eyelids are always half-closed, to keep the flies out of their eyes, they being so troublesome here that no fanning will keep them from coming to one's face; and without the assistance of both hands to keep them off, they will creep into one's nostrils, and mouth too, if the lips are not shut very close. So that from their infancy, being thus annoyed with these insects, they do never open their eyes as other people, and therefore they cannot see far, unless they hold up their heads, as if they were looking at somewhat over them.'

This graphic description by Dampier is as true to-day in Central Australia as it was in his day. The fly concerned is a native fly, *Musca vetustissima*. We all know how persistent it is when we go for a walk through the bush in summer-time, the flies being so troublesome that no fanning will keep them from coming to one's face. They take every opportunity of abstracting moisture and nutriment from the tears in the corners of the eyes and the saliva round the mouth, and the blood from any recent scratch. One can readily see, therefore, that the infection of 'erkintja' the native name for yaws can be spread by these persistent creatures from an infected sore in one child to a scratch on another.

This species of fly is indigenous to Australia, and strange to say has not yet acquired the habit of entering into our houses, although they may enter more or less open tents. The flies that occur indoors are introduced species, more particularly *Musca domestica*. As a result of these differences in habits, the bush fly plays little part in the spread of typhoid fever in Australian communities, whereas the domestic fly is undoubtedly frequently responsible.

## SUMMARY AND CONCLUSION

In this brief survey some aspects only of the ecology of primitive man in Tasmania and Australia have been considered. No reference has been made to his implements, handicrafts and art, or to the sources and nature of the materials used for these purposes; none to the Australian native's interpretation of natural objects as representing the doings of ancestral beings; none to the skill in tracking and hunting game or to the habits as they affect the hunter of the animals so hunted; none to many other sides of the complicated relationships that exist between man and his natural surroundings. I have merely taken some aspects that have appealed to me particularly as a naturalist and many of which I think would have appealed to Clive Loid also. I have tried to show that the country to which these peoples came was neither literally nor metaphorically flowing with milk and honey. Nevertheless they overcame with remarkable success the difficulties that presented themselves and obtained food and water often from unusual sources and in unexpected ways. I have shown that through the absence of suitable plants to cultivate and animals to domesticate they could not control their environment by growing food-stuffs or keeping flocks and herds and so remained or became food-gatherers only. Though often destitute of coverings and so going naked by day and night, their skilful use of little fires and physiological changes that sophisticated man has lost have enabled them to control the deleterious factor of cold. One important effect of the environment has been the grinding down of the teeth through the frequent incorporation of sand and grit in the diet and the fibrous nature of much of the food; the use of native tobacco and pitum as narcotics has also been mentioned. Fire has been the only means by which they have altered their environment and that probably only to a trifling extent. Epidemic diseases for reasons stated were almost non-existent.

In conclusion, may I say that the Australian native is a very likeable being, as doubtless was the Tasmanian. The latter has passed away as a pure race and the former, I regret to say, seems to be passing away too. Civilization seems to have been fatal to each; with detribalization, the interest in life ceases. Removed from their own country with its ancestral associations they languish and die. Grave wrongs have been done to many. But even kindness and fostering care and patient endeavour have proved unable to stem the tide of decay. Through all the ages have descended the bloods of these two ancient races of man, of man who is the acme of evolution. In the clash of worldly interests, I see little hope for the continued existence of the pure-blood Australian native beyond a few scores of years. But of both races there are descendants of mixed blood. The aboriginal element in them, I am convinced, is by no means an undesirable one. The same may be said of the European side, when it came from sturdy pioneering stock. The task before us now, in Tasmania and in Australia, is not to keep these folk segregated, but to fit them for taking their place in our social organization. There can be no other solution. Gradually absorption will occur, and thus the blood of the ancient Tasmanian and Australian races will, I trust, live on in the veins of some at least of our successors in this Island and in this Commonwealth, and not to their disadvantage.

*Acknowledgments.* In the preparation of this paper I would like to express my acknowledgment for help in many and various ways, including the loan of photographs and slides, and for information to Dr. W. Crowther, Dr. J. Pearson and Dr. J. W. Evans of Hobart; to Professor Agar, Dr. J. Wunderly, Mr. A. H.

Chisholm and Mr. H. E. Dadswell of Melbourne; and to Professor Harvey Johnston, Dr. T. D. Campbell, Mr. N. B. Tindale and Mr. C. P. Mountford of Adelaide.

## REFERENCES

- Bews, J. W., 1935.—*Animal Ecology*. London.
- CAMPBELL, T. D., 1939.—Food, Food Values and Food Habits of the Australian Aborigines in Relation to their Dental Conditions *The Australian Journal of Dentistry*. Parts I. to V. Jan. to June.
- CLELAND, J. B., 1928.—Disease amongst the Australian Aborigines. Reprinted from the *Journal of Tropical Medicine and Hygiene*. 63 pages.
- DAMPIER, WILLIAM, 1697.—A New Voyage round the World in *The English Circumnavigators* (Nimmo, undated).
- HACKETT, C. J., 1938.—Boomerang Lek and Yaws in Australian Aborigines. *Royal Society Tropical Medicine and Hygiene*, Monograph I. 1937 (1938).
- HERBERT, D. A., 1938.—Proc. Roy. Soc. Queensland, XLIX, 1937 (1938) pp. 145-149.
- HICKS, SIR C. STANTON, AND O'CONNOR, W. J., 1938.—Skin Temperature of Australian Aborigines under varying Atmospheric Conditions. *Australian Journal of Experimental Biology and Medical Science*. XVI, Pt. 1, pp. 1-18.
- HOCKINGS, H. J., 1884.—Notes on two Australian species of *Trigona*. Trans. Entomo Soc. Lond.
- JOHNSTON, T. H., AND CLELAND, J. B., 1933-1934.—The History of the Aboriginal Narcotic, Pituri (*Ocotea*, IV, No. 2, pp. 201-223, and No. 3, pp. 268-289).
- KOHLER WOLFGANG, 1925.—*The Mentality of Apes*. London.
- MAGAREY, A. T., 1895.—Aboriginal Water Quest. *Proc. Roy. Geogr. Soc. Australasia (S. Austr. Branch)*, Session 1894-5 and Report Australasian Association Advancement of Science, 1895, pp. 647-658.
- MORRIS, E. E., 1898.—*Austral English. A Dictionary of Australian Words, Phrases and Usage*. London.
- PERON, M. F., 1809.—*A Voyage of Discovery to the Southern Hemisphere*. Translated from the French. London.
- RAYMENT, T., 1935.—*A Cluster of Bees*. Sydney.
- ROTH, H. LING, 1890.—*The Aborigines of Tasmania*. Halifax.
- RODWAY, L., 1903.—*The Tasmanian Flora*. Hobart.
- SMYTH, R. BROUGH, 1878.—*The Aborigines of Victoria*. Melbourne.
- SPENCER, (SIR) BALDWIN, AND F. J. GILLEN, 1912.—*Across Australia*. London.
- STEADMAN, F. ST. J., 1937.—Malocclusion in the Tasmanian Aborigines. *The Dental Record*, LVII, pp. 213-219.
- TILLYARD, R. J., 1926.—*The Insects of Australia and New Zealand*. Sydney.
- WALKER, JAMES BACKHOUSE, 1914.—*Early Tasmania*.
- WHEELER, HELEN, 1935.—Studies in *Nicotiana*. *University of California Publications in Botany*. Vol. 18, pp. 45-68.
- WILLS, W. J., 1861.—*The Burke and Wills Exploring Expedition, etc.* Melbourne. Wills' Journal, p. 28.
- , 1862.—Burke and Wills Commission. Report. Parliamentary Paper, Melbourne.
- , 1863.—'Wills' Journal, edited by his father, William Wills, under the title 'A successful exploration through the Interior of Australia'. London.
- WUNDERLY, J., 1938.—The Origin of the Tasmanian Race. *Man*, XXXVIII, pp. 198-200.
- , 1939.—The Cranial and other Skeletal Remains of Tasmanians in Collections in the Commonwealth of Australia. *Biometrika*, XXX, pts. III and IV, pp. 305-340.

## PLATE I

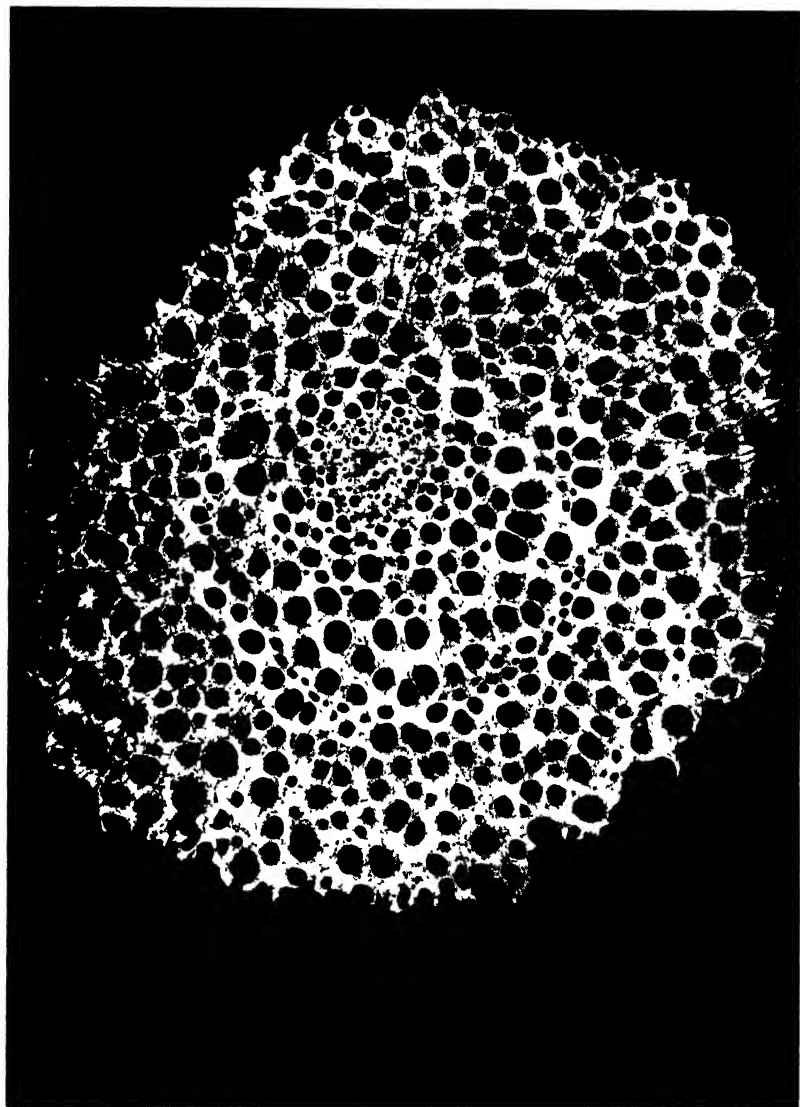
- FIG. 1.—Looking for a bees' nest. Men and boys searching the ground for small dark particles 1 mm. diameter, carried away from the nest by the bees. If found, they indicate that a bees' nest is near. Macdonald Downs, Central Australia. (Photo by Professor T. Harvey Johnston.)
- FIG. 2.—Woman dehussing grain by movements of the feet in a hole in the ground. She is partly supporting herself against a mulga stem. Macdonald Downs, Central Australia. (Photo by Professor Wilkinson.)
- FIG. 3.—Adornment of the Person. Young woman with the tips of strands of hair forced into the orifices of 'gum nuts' (*Eucalyptus* capsules). Warburton Ranges, W. Australia. (Photo by O. Stocker.)
- FIG. 4.—Adornment of the Person. Young man with hair arranged in a chignon and cheloid body scars. Another with a bone placed through a hole in the nasal septum. Mt. Liebig, Central Australia. (Photo by Professor T. Harvey Johnston.)





PLATE II

Small water-bearing root of the Mallee *Eucalyptus transcontinentalis*, 5.5 mm diam. The available pore area is 32.3 per cent Ooldea, S. Australia (Photo by H. E. Dadswell, Division of Forest Products, C.S.I.R., Melbourne).





# Notes on the systematics of two species of *Heterodoxus* (Mallophaga, Boopidae)

By

N. J. B. PLOMLEY, B.Sc.

(Read 13th November, 1939)

## PLATES III-VI

The problems here considered are, first, the systematics of the lice of the genus *Heterodoxus* Le Souéf and Bullen, occurring on the domestic dog and certain other monodelphian mammals, and, secondly, the question of their identity with members of the genus occurring on didelphian mammals (marsupials). Upon marsupials, apparently the true hosts, the genus appears to be confined to the Macropodidae.

### DIAGNOSIS OF SPECIES, HOST RECORDS

Genus ***Heterodoxus*** Le Souéf and Bullen

***Heterodoxus longitarsus*** (Piaget). Genotype

*Menopon longitarsus* Piaget (1880), pp. 504-506, pl. XLI, f. 7, *Halmaturus giganteus*, (Zoo Rotterdam)

*Heterodoxus macropus* Le Souéf and Bullen (1902), p. 159, f. 11, Kangaroos, Wallabies, &c.

Type host: *Halmaturus giganteus* = *Macropus major* (Shaw).

Notes: The Piaget Collection in the British Museum (Natural History) includes four slides marked '*Menopon longitarsus*', a total of 3 ♂♂, 3 ♀♀, 3 ○○. Two slides, with 1 ♂, 1 ♀ mounted on each, are labelled '*Menopon longitarsus*, sur un Kangourou, *Halmaturus giganteus*', the other slides, '*Menopon longitarsus*, sur un Kangourou'; the former are to be considered the types since a definite host is designated.

Unfortunately, I have not been able to examine these specimens critically, nor have I been able to obtain any material from the type host. Since it is more than likely that *Heterodoxus* will show definite host specificity, I consider that *Heterodoxus longitarsus* (Piaget) from *Macropus major* (Shaw), is a definite species and distinct from *H. spiniger* (Enderlein) and from *H. ulabati*, sp. nov.

***Heterodoxus spiniger*** (Enderlein)

*Menopon spiniger* Enderlein, (1909), pp. 80-81, pl. VIII, f. 4, 5, ('von Haushund eines Betschuanen, auf den es wohl von einem Beuteltiere gelangt ist.')

*Heterodoxus armiferus* Paine, (1912), p. 362, f. A-D: (dog).

*Heterodoxus longitarsus* auctorem (non-marsupial hosts).

*Type Host*: 'Haushund' = *Canis familiaris* Linné.

*Hosts*: (A) Marsupial: *Wallabia bicolor* (Desmarest); (B) Non-marsupial: *Canis ochropus* Eschscholtz ('Coyote'), *Herpailurus salinarum* Thomas ('*Oncifelis salinarum*') 'Jackal', 'Man', *Canis familiaris* Linné.

*Specimens examined*: *Note*:—Certain of these specimens are those upon which previous authors have based descriptions, records, &c., and are indicated accordingly.

'Jackal', Uganda, Arua, 2.iii.1931, T. W. Chorley, 1 ♂, 2 ♀♀; '*Canis famil.* (juv.)', Belgian Congo, Katanga, Bukama, 18.x.1931 series ♂♂, ♀♀; 'Cocker Spaniel', Tasmania, Launceston, 24.i.1934, N. J. B. Plomley, 1 ♂, 2 ♀♀; 'Dogs', Dutch New Guinea, Geelvink Bai, iv.1929, Malte von Kühlewein, 1 ♂, 3 ♀♀; 'Puppies', Australia, N.S.Wales, Gulargambont 18.vi.1933, R. N. McCulloch, 1 ♂, 1 ♀, 1 ♂ (McCulloch, (1933)); 'Dog', Japan, Yokohama, 24.iv.1902, 1 ♀; 'Dog', China, Hangchow, 1 ♀; 'Dog', Brasil, Rio de Janeiro, 2 ♂♂, 5 ♀♀; 'Dogs', Malaya, Kelantan, Kota Bharu, 12.xi.1912, 1 ♂, 1 ♀; 'Dog', Dutch New Guinea, N. coast Schoutein Is., Warsa, 1.ii.1930, M. von Kühlewein, 2 ♂♂, 7 ♀♀; *Wallabia bicolor* (Desmarest), Australia, Victoria, 2 ♂♂; 'Coyote', U.S.A., California, Santa Cruz, 1916, G. F. Ferris, 1 ♂, 1 ♀ (Ferris (1922)); 'Dog', U.S.A., California, Berkeley 7.x.1909, Herms, 1 ♂, 1 ♀ (types *Heterodoxus armiferus* Paine) (Paine (1912)); 'Man', Fed. Malay States, Kuala Lumpur, xi.1915, S. T. Darling, 1 ♀ (Ferris (1922)); 'Domestic Dog', Columbia, Villeta Dept., Cundinamarca, 1936, J. Bequaert, 1 ♂; 'Dog', Hawaii, Honolulu, 15.iii.1933, C. E. Pemberton, 1 ♂, 2 ♀♀; 'Dog', Java, Toeloengogoeng, 21.ix.1932, C. J. Louwerens, 4 ♂♂, 1 ♀; 'Dog', Java, Toeloengogoeng, 6.x.1932, C. J. Louwerens, 2 ♂♂, 1 ♀; 'Dog', Cuba, Havana, 6.x.1932, Dr. Terez Vigueira, 3 ♂♂; 'Off large, black, short-haired, adult ♀ dog', Canal Zone, R. Chagres, Gatuncillo, 19.i.1932, L. H. Dunn, 1 ♂, 1 ♀; *Oncifelis salinarum*, Argentina, Jujuy, F. L. Werneck, 1 ♂, 1 ♀ (Werneck (1936)); 'Dog', U.S.A., Missouri, State College, iv.1935, F. W. Stafford, 5 ♂♂, 5 ♀♀; 'Dog', U.S.A., Oklahoma City, 5.vi.1933, J. W. Ward, 1 ♂, 1 ♀ (Ward (1934)); *Canis familiaris*, S. Africa, Kalahari, 1910, (error = 1904), 1 ♀ (type *Menopon spiniger* Enderlein) (Enderlein (1909)); 'Chien Terre Neuve', Martinique, i.1896, 1 ♀ (Neumann (1912b)); 'Chien', Japan, Yokohama, 1909, C. N. Rothschild, 1 ♂, 1 ♀ (Neumann (1912b)); *Canis familiaris*, Formosa, Kosempo, vii.1911, 1 ♂, 1 ♀ (Neumann (1913)); *Canis familiaris*, Malay Peninsula, xi.1912, Dr. Gimlette, 1 ♀ (Neumann (1913)); 'Chien de laboratoire', Mozambique, Lourenço Marques, 9.iv.1910, Howard, 2 ♂♂, 1 ♀ (Neumann (1912b)); 'Dog', Australia, Queensland, Goondiwindi, 28.v.1936, F. H. S. Roberts, 3 ♂♂, 11 ♀♀, 6 ♂♂ (Roberts (1936)); 'Dog', India, Calcutta School of Tropical Medicine, 63 ♂♂, 74 ♀♀, 59 ♂♂; 'Dog', Porto Rico, Mayaguez, 22.iv.1936, 22 ♂♂, 43 ♀♀, 10 ♂♂.

*Diagnosis*. General facies typical of genus. Plate III, figs. A-J; Plate IV, figs. A-B, D-K; Plate V, figs. A, C-G; Plate VI, figs. B, C: show details of head, thorax and abdomen; Table 1 gives an analysis of measurements and counts. Distinguished from other species on the structure of the phallus in the male. Posterior border of tergite of last abdominal segment in ♂ bears 12-63 (S.D.n-1 = 1.54) spines, that of last abdominal sternite in ♀ 17-77 (S.D.n-1 = 1.75) spines; the setae are arranged in a discontinuous band or nearly so in both sexes, there being a median gap in the row dividing it right and left. Metathoracic sternal sclerite bears six setae, with intersetal distances as tabled. Setae arranged on metathoracic tergite as figured.

**Heterodoxus ualabati** sp. nov.

♂ *Heterodoxus macropus* Paine (1912) (nec Le Souef and Bullen, (1902)), p. 361, f. E-G 'Black Wallaby'.

? *Heterodoxus longitarsus* Harrison and Johnston (1916) (nec Piaget, (1880)), f. 11, *Macropus dorsalis* (= *Wallabia dorsalis* (Gray)).

**Type Host:** 'Black Wallaby', Victoria = *Wallabia bicolor* (Desmarest) (1).

**Specimens examined:** 'Black Wallaby', Victoria, A. S. Le Souef, 2 ♂♂, ('type specimens' *Heterodoxus macropus* Paine) (Paine (1912)); *Wallabia bicolor* (Desmarest), Sydney Zoo, 10.v.1927, 5 ♂♂; *Wallabia bicolor* (Desmarest), Victoria, 4 ♂♂.

**Diagnosis.** General facies typical of genus. Plate III, fig. K; Plate IV, figs. (A), C, (E), L; Plate V, figs. (A), B, H; Plate VI, fig. A: show details of head, thorax and abdomen. Table 1 gives an analysis of measurements and counts. Distinguished from other species on the structure of the phallus in the male. Posterior border of tergite of last abdominal segment in ♂ bears about 22 spines, arranged in a continuous band. Metathoracic sternal sclerite bears six setae, with intersetal distances as tabled. Setae arranged on metathoracic tergite as figured. Female not known.

## DESCRIPTION

**Head.** Shape conical, bluntly rounded anteriorly and the postero-lateral angles acute. Chaetotaxy very constant in disposition, but setae subject to some variation in relative length and strength. Plate III shows these features for a number of individuals of *H. spiniger* and *H. ualabati*. The head structure appears generically constant.

**Thorax.** Plate IV, figs. A, E show dorsal and ventral views of the thorax of an *H. spiniger*; the thorax has a similar structure in *H. ualabati*, and, except for the chaetotaxy of the metathorax, appears to be generically constant. Three segments are to be distinguished dorsally and ventrally. The chaetotaxy of the prothoracic and mesothoracic tergites is constant, that of their sternites variable. The prothoracic tergite is an oval plate (Plate IV, figs. A-C); on the sternite is a heart-shaped sclerite (2) bearing a number of setae (Plate IV, figs. E-H). These setae comprise:—(1) a series of three on each side (Plate IV, fig. F, 'x', 'y', 'z'), which are of almost constant occurrence, and (2) others of very variable disposition, though they show some tendency to comprise a few longer setae posteriorly and a row of shorter ones anteriorly. The width of this plate (see Table 1, intersetal distance 'xx') is expressed by the distance between the two anterior spines 'x'.

The mesothorax is poorly developed dorsally, where it bears only a pair of spines; ventrally it is more extensive, and bears a variable number of spines, which show little regularity of arrangement though a tendency to occur in two bands which diverge anteriorly.

The metathoracic tergite is of rectangular shape (Plate IV, figs. A, D). In *H. spiniger* and *H. ualabati* (♂) it bears posteriorly a median pair of long hairs with a pair of short spines at the lateral angles, and centrally a row of six long setae with some short ones laterally. In both species the sternum bears an ill-defined plate upon which there are three pairs of setae, the occurrence and disposition of which are very constant; only very occasionally are extraneous setae present (Plate IV, figs. E, I-L).

(1) Personal communication from Mr. A. S. Le Souef

(2) The pair of hairs situated at the anterior margin of the sclerite, sometimes included in it and sometimes outside it, and the similar pair between the plate and the mesothorax, occur regularly. They are not considered in counts for Table 1

**Abdomen.** (Plate V, fig. A). The tergum, sternum and pleura of each segment bear setae, those of the tergum tending to be merged with those of the pleura. The spiracles are dorso-lateral; on segments 1-3 there are dorso-lateral sense organs (Plate IV, fig. A; Plate V, fig. A; 'so'). Though the lengths of the setae intergrade, in contrast to great variability among the smaller, the largest show constancy of numbers and distribution. Dorsally the setae of each segment form an irregular row, the smaller ones scattered amongst the largest, while ventrally they tend to be arranged in two rows, the largest in a posterior row which has no interspersed smaller setae. Thus a formula may express the numbers of these largest setae on tergum and sternum; for segments 1-6 inclusive, in *H. spiniger* and *H. ualabati*, it is:— (dorsal/ventral) 4/4, 6/6, 6/6, 6/8, 6/8, 6/8.

**Terminalia.** (Plate V, figs. B-H; Plate VI, figs. A, B). The terminalia in *H. spiniger* and *H. ualabati* are of the same general type, and consist of the modified terminal segments of the abdomen in male and female, and of the external genitalia in the male. Terminology is that used by Snodgrass (1935).

The terminal abdominal segments in male and female have their tergal and sternal plates modified as copulatory processes by the development of a row of stout setae ('sr') along the posterior border of the sclerite (Plate V, figs. B-D). It is probable that these setae help to hold the individuals in copulation, the two series becoming interlocked. This row of setae occurs on the tergum in the ♂ and on the sternum in the ♀, and so it is to be expected that the ♀ rides on the ♂ during copulation (c.f. Werneck (1936), pl. 1).

In *H. spiniger* and *H. ualabati*, the external genitalia of the ♂ (Plate V, figs. E-H; Plate VI, figs. A, B) consist of an apodemal plate and a phallus. The apodemal plate (Plate V, fig. E, 'ap') has upraised sides posteriorly; to these sides are hinged the parameres (Plate V, fig. E, 'pm'), and posterodorsally, a flap (Plate V, fig. E, 'f'). Near the hinge points of the flap arise a pair of lightly-chitinized bars (Plate VI, fig. A, 'b'), so that the base of the phallus is supported by the bars and the apodemal plate ventrally and by the flap dorsally. The flap does not appear to be hinged directly to the apodemal plate, but indirectly via a pair of rods shaped like blunt thorns, which are hinged in turn to the apodemal plate, above the hinge points of the parameres.

The phallus is a thin-walled tube, bearing a series of processes and spines (Plate V, figs. E, 'ph'; F-H). In general its structure is the same in *H. spiniger* and *H. ualabati*, but there are differences of detail in the two species. Unfortunately, owing to lack of material, dissections were possible only for *H. spiniger*, so that the details of the phallus structure (particularly the central area) in *H. ualabati* were not followed as thoroughly as was hoped, Plate V, fig. H, being a diagrammatic reconstruction from the introvert phallus, based on the structure of the extrovert phallus in *H. spiniger*.

The phallus in *H. spiniger* (Plate V, figs. E-G; Plate VI, fig. B) may be divided into a lightly-chitinized basal region ('r' 1), a central region bearing various processes ('r' 2), and a lightly-chitinized terminal region ('r' 3). The basal region is a simple tube. The central region bears two prominent lateral processes ('lp'), and a ventral beak-like structure ('bk') having at its sides two small processes ('p'); there are no processes dorsally. The lateral processes bear distally on their outer edges heavily-chitinized concavities; they do not bear teeth. The lateral processes and the beak-like structure are strengthened by sclerotizations (Plate V, fig. G, 'sc' 1-'sc' 4). The terminal region of the phallus bears two rows of three spines ('st') and is covered, over most of its area, with small spinules; this character of the two rows of spines is a specific one in this species. The retracted phallus

has its processes lying within the tube, and, in situ, therefore shows inversion of the tube only; on eversion, the processes come to lie on the outer surface of the tube so formed.

The phallus in *H. ualabati* (Plate V, fig. H; Plate VI, fig. A) differs from that in *H. spiniger* as follows. The central region, of which the detailed structure was not determined, bears two prominent lateral processes ('lp' 1), which have their distal margins toothed. The terminal region of the phallus bears two sac-like structures ('ss') covered with spinules; no spines are to be found such as occur on this region in *H. spiniger*.

#### MEASUREMENTS AND COUNTS

In Table 1 is set out a summary of measurements and counts referring to *H. spiniger* and *H. ualabati*. The measurements were made with an ocular micrometer; This was calibrated against a stage micrometer and the absolute measurements interpolated after summarizing. The setal counts refer to the total number of setae occurring on the sclerite, except those made in connexion with the terminalia which refer only to a particular row of setae (Plate V, figs. B-D, 'sr'). Only mature males and females were considered. The selection of individuals for statistical analysis was qualitative, the criteria being the structure of the phallus for the male, and occurrence on non-marsupial hosts for females of *H. spiniger* (since only one type of male was found on such hosts; the results of the analyses support such selection). It must always be remembered that the measurements were made on specimens mounted on slides; such mounting results in some degree of distortion.

It is seen that while characters such as the number of setae sternal plate 1st thoracic segment, number of setae 1st tergite abdomen, are generic characters, significant differences exist for other characters. It is impossible to assess the value of such differences in the absence of material representing the genus as a whole, for until the whole has been examined the possibility that intermediate types may exist must always be kept in mind. Should difficulties arise when the whole genus has been surveyed, it may still be possible to characterize species by a group of measurements.

TABLE 1

	Number	Mean	Max	Min	S.D. (n-1).
<i>H. spiniger</i> : head width mm	70 ♂ ♀ 29 ♂ ♂ 41 ♀ ♀	0.640 0.638 0.642	0.700 0.700 0.700	0.568 0.581 0.568	0.031 0.031 0.031
<i>H. ualabati</i> :	11 ♂ ♂	0.698	0.719	0.680	0.013
<i>H. spiniger</i> : head length mm.	70 ♂ ♀ 29 ♂ ♂ 41 ♀ ♀	0.423 0.420 0.426	0.462 0.462 0.462	0.383 0.383 0.381	0.021 0.023 0.020
<i>H. ualabati</i> :	11 ♂ ♂	0.480	0.502	0.462	0.019
<i>H. spiniger</i> : ratio: head width : head length (calculated from the separate values).	70 ♂ ♀ 29 ♂ ♂ 41 ♀ ♀	1.51 1.52 1.50	1.67 1.60 1.67	1.44 1.43 1.34	0.054 0.042 0.060
<i>H. ualabati</i> :	11 ♂ ♂	1.45	1.51	1.39	0.044
<i>H. spiniger</i> : setae sternite 1 thorax (n = 2 (x + y + z) + a).	71 ♂ ♀ 28 ♂ ♂ 43 ♀ ♀	17.96 18.04 17.91	23 21 23	13 13 14	2.24 2.20 2.26
<i>H. ualabati</i> :	11 ♂ ♂	18.55	21	16	1.20



	Number.	Mean	Max.	Min	S.D. (n-1).
<i>H. spiniger</i> : sternite 1 thorax, intersetal distance xx mm.	25 ♂ ♀	0.156	0.181	0.133	0.012
	15 ♂ ♂	0.153	0.169	0.133	0.010
	10 ♀ ♀	0.160	0.181	0.145	0.013
<i>H. ualabati</i> :	5 ♂ ♂	0.194	0.207	0.183	0.010
	75 ♂ ♀	a 0.189 b 0.092 c 0.087	0.215 0.106 0.106	0.188 0.079 0.068	0.010 0.007 0.009
<i>H. spiniger</i> : sternite 3 thorax, intersetal distances mm	32 ♂ ♂	a 0.188 b 0.093 c 0.086	0.208 0.105 0.106	0.168 0.081 0.068	0.011 0.007 0.010
	43 ♀ ♀	a 0.191 b 0.092 c 0.087	0.215 0.106 0.103	0.174 0.079 0.071	0.010 0.007 0.008
<i>H. ualabati</i> :	7 ♂ ♂	a 0.224 b 0.109 c 0.121	0.242 0.118 0.134	0.211 0.100 0.108	0.012 0.007 0.010
<i>H. spiniger</i> : setae tergite 1 abdomen (n = 4 + a)	66 ♂ ♀	17.11	21	13	1.75
	27 ♂ ♂	16.74	19	13	1.51
	39 ♀ ♀	17.36	21	13	1.89
<i>H. ualabati</i> :	9 ♂ ♂	15.67	19	14	1.73
<i>H. spiniger</i> : setae tergite 8 abdomen ♂	30 ♂ ♂	Left 6.40 Right 6.23 Total 12.63	8 8 15	5 5 10	0.98 0.82 1.54
<i>H. ualabati</i> :	Total: Counts (latter four doubtful). 19, 22, 23, 23, (20, 20, 25, 25) Approx mean 22				
<i>H. spiniger</i> : setae sternite 8 abdomen ♀	39 ♀ ♀	Left 8.95 Right 8.82 Total 17.77	11 11 21	7 7 14	1.05 0.97 1.75

## SEX RATIO

A summary of data for specimens of *H. spiniger* infesting the dog shows a general preponderance of females over males. The only total count ('Dog', Canal Zone: 96 ♂♂, 122 ♀♀) gives a sex ratio of 79♂♂ to 100♀♀. However, in view of the findings of Buxton (1937) these results have little or no significance.

## NOTES

The genus *Heterodoxus* was defined by Le Souëf and Bullen (1902) for an amblycerous parasite of 'Kangaroos, Wallabies, &c.', *H. macropus*, which they described. Johnston and Harrison (1913) and Harrison and Johnston (1916) re-examined Le Souëf and Bullen's material and concluded that, in view of the wide range of variation found, *H. macropus* was identical with Piaget's *Menopon longitarsus*, also assigning to the species specimens from several macropods and from dogs. They direct attention, however, to the chaetotaxy of the thoracic sternites and to the genitalia.

Specimens examined include many of those upon which previous records have been based, and much of the Harrison and the Le Souëf and Bullen collections. Unfortunately, no material was available from several of the species listed by Harrison and Johnston (1916) as hosts of '*H. longitarsus*'. Material in the Le Souëf and Bullen collection labelled '*Heterodoxus macropus*' comprised more than one species, so that the status of *H. macropus* could not be determined definitely and the species must be ranked as a synonym of *H. longitarsus* (Piaget). Mr. A. S. Le Souëf informs me that no specimens of *H. macropus* were designated types. Froggatt (1907) labels his figure as 'drawn from the type', but this will be a mistake.

## DISCUSSION

The genus shows great constancy in the series examined; this, with the great individual variation, makes species diagnosis difficult. The parasites from a host individual tend to group together and to show some constancy; the body proportions, the number of setae on a particular sclerite, in a series from one host individual may differ markedly in that from another, but this definiteness is not apparent when the several series are considered together. Certain characters show much greater individual variation than others, and belong to the group as a whole rather than to the species.

A classification based on morphology alone is not possible for both sexes, for while the structure of the phallus permits species differentiation in the male, there is no one other character of absolute diagnostic value. This means that the female may be associated definitely with the male only after: (1) examination of long series of individuals, collected from known hosts, with special attention paid to the possibility of regional distribution on the host's body; (2) mating and breeding experiments (association of the sexes of *H. spiniger* is possible because of the abnormal host relations shown by this parasite). Although it may be found possible to delimit species by a series of characters considered together, and the findings for *H. spiniger* would indicate this, at present the number of individuals available for examination is so small that no attempt is warranted.

In elaborating a scheme of classification in the genus it would seem that attention should be paid to the following points:—(1) the structure of the phallus in the male, (2) arrangement of setae on the terminal abdominal segments, (3) arrangement of setae on the metathoracic tergite and sternite, the abdominal sternites and, doubtfully, the prothoracic sternite, (4) measurements for head and thorax, of which those considered here might form a basis. It may be argued that environment may influence the distribution of setae on the ventral surface, but this does not seem to hold since: (a) the tergal chaetotaxy of the metathorax and that of the terminal abdominal segment in the male, appear to have a specific value, (b) all specimens from non-marsupial hosts have the same chaetotaxy as well as phallus structure, and it seems reasonable to suppose that the environments offered are various, (c) a series from an individual *Wallabia bicolor* comprised two species on phallus structure, although the possibility of each being confined to a definite region of the body must be remembered.

To summarize, the investigation has done little but present a number of problems for future study and until very much longer series, from all hosts, have been examined critically, the issue must remain indefinite. Are the species here outlined but variants of the one natural group, the limits of which have yet to be defined, that is, but one species, 'a population the members of which form a genetically interlinked complex' (Ferris, 1935)? Or are we dealing with a case of convergence? The internal anatomy of the various forms has not been studied. Of 79 specimens from various marsupials (Macropodidae) I can assign only two males to the same group as those examined from non-marsupial hosts, which all belong to the same group, a fact which emphasizes our ignorance of the physiology of host specificity. No experimental infections and cross-infections were carried out. Finally, it is of interest that *Heterodoxus* has not been recorded from the Australian Dingo (*Canis dingo* Meyer), though admittedly there are but two records of ectoparasite examinations of this host, a *Trichodectes* being found in each case; I have seen a series of lice from a dingo and they were also a species of *Trichodectes*. Does *Heterodoxus* occur on the dingo; if not, why not? Mr. A. Arnold informs me that his trappers report ectoparasite infection of the dingo to be of rare occurrence in West Australia.

Ferris (1930) has recorded six parasite species from a single host individual. In the material examined by me four species of *Heterodoxus* (based on phallus structure) have *Wallabia bicolor* as host, a series from one host individual containing two species of *Heterodoxus*. It is to be emphasized, however, that some of the parasites were from animals in zoological gardens; moreover, a species may be confined to some region of the host's body, and hybridization may be possible.

Although it is not possible to assess much of the literature relating to *Heterodoxus*, records from non-marsupial hosts can all be assigned to *H. spiniger* with some degree of certainty.

I should like especially to thank Professor E. J. G. Pitman for his help with the statistical analyses. To Professor W. S. Patton I am indebted for helpful criticism.

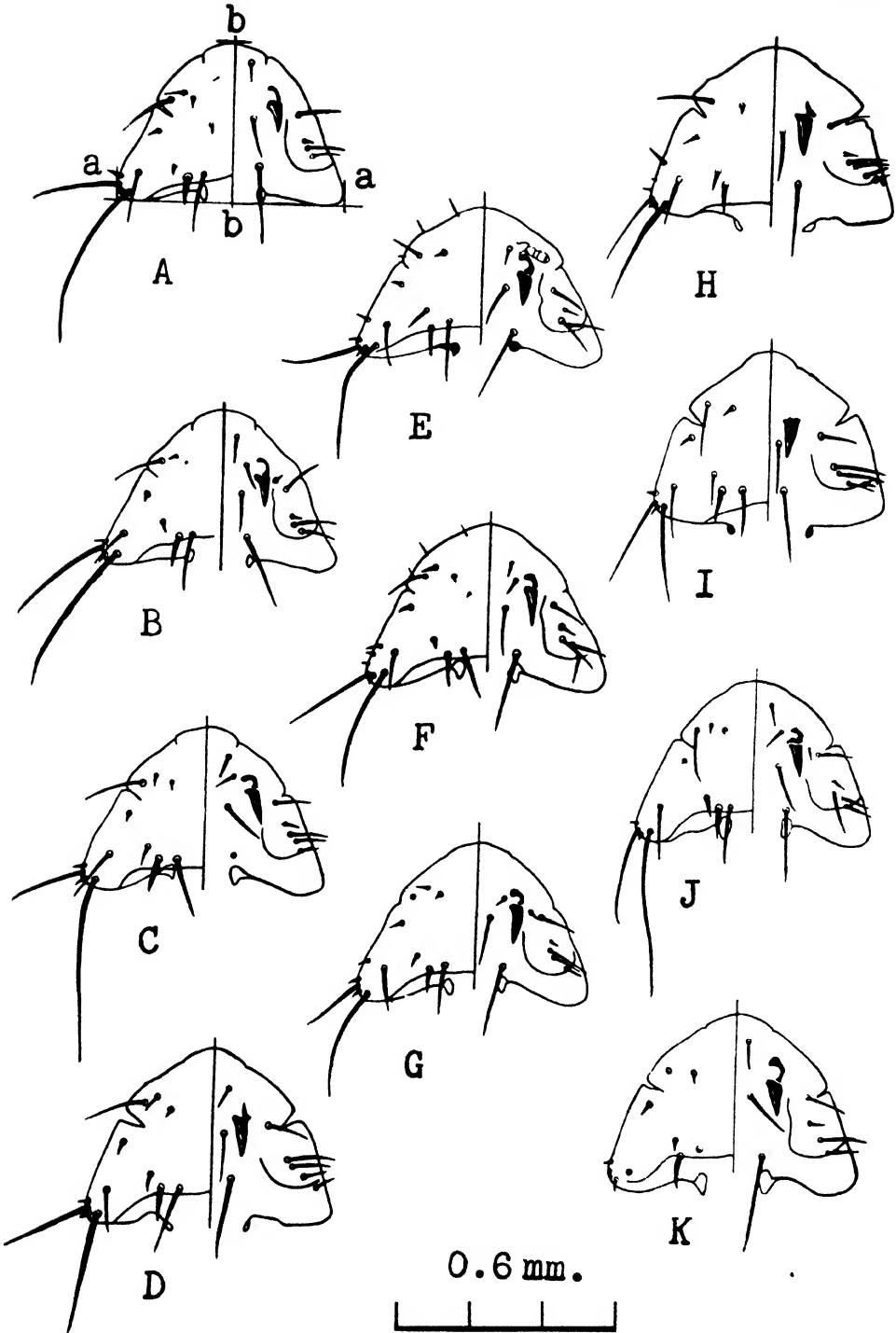
#### REFERENCES

- BUXTON, P. A., 1937.—Numbers of males and females in natural populations of head lice (Pediculus, Anoplura). *Proc. R. ent. Soc. A*. XII. pts. 1-2. pp. 12-14.
- ENDERLEIN, G., 1909.—Anopluren (Siphunculaten) und Mallophagen. (L. Schultze, Forschungsreise in westlichen und zentralen Sudafrica ausgeführt in den Jahren 1903-1905). *Denkschr. med.-naturw. Ges. Jena*. XIV. pp. 80-81. pl. VIII. f. 4, 5.
- FERRIS, G. F., 1922.—Concerning lice. *J. Mammal.* III. p. 17.
- , 1930.—Report upon certain ectoparasites of mammals. In Strong, *Afr. Repub. Liberia* II. pp. 1023-1024.
- , 1935.—Contributions toward a monograph of the sucking lice. VIII. *Stanford Univ. Publ. Biol. Sci.* II. no. 8. p. 7 (533).
- FROGGATT, W. W., 1907.—*Australian insects*. Sydney. pp. 390. f. 175.
- HARRISON, L., AND JOHNSTON, T. H., 1916.—Mallophaga from marsupials. I. *Parasitology*. VIII pp. 353-354. f. 4, 10, 11.
- JOHNSTON, T. H., AND HARRISON, L., 1913.—A census of Australian Mallophaga *Proc. roy. Soc. Qd.* XXIV. p. 13.
- LE SOUEF, S. A., AND BULLEN, H., 1902.—Description of a Mallophagous parasite from the kangaroo. *Vict. Nat.* XVIII. p. 159. f. 11.
- MCCULLOCH, R. N., 1933.—A kangaroo louse infesting dogs. *Agri. Gaz., N.S.W.* XLIV. pt. 8. pp. 617-619. fig.
- NEUMANN, L. G., 1912a.—Notes sur les Mallophages. II. *Arch. Parasit. Paris*. XV. pp. 359-360. f. 5.
- , 1912b.—*Menopon (Menacanthus) spinigerum* Enderlein 1909 . . . . . *Arch. Parasit. Paris*. XV. pp. 364-365. f. 12.
- , 1913.—Notes sur les Mallophages. III. *Arch. Parasit. Paris*. XV. pp. 631-634.
- PAINE, J. H., 1912.—The Mallophagan genus *Heterodoxus* Le Souef and Bullen. *Ent. News*. XXIII. pp. 359-362. f. A-G.
- PIAGET, E., 1880.—*Les Pédiculines*. Leiden. pp. 504-506. pl. XLI. f. 7.
- ROBERTS, F. H. S., 1936.—Gross infestation of the dog with the kangaroo louse *Heterodoxus longitarsus* (Piaget). *Aust. vet. J.* XII p. 240.
- SNODGRASS, R. E., 1935.—*Principles of insect morphology*.
- WARD, J. W., 1934.—*Proc. Okla. Acad. Sci.* XIV. pp. 22-23. f. i, ii.
- WERNICK, F. L., 1936.—Contribuição ao conhecimento dos Mallophagos encontrados nos mamíferos sul-americanos. *Mém. Inst. Osw. Cruz*. pp. 492-495. f. 126-129. pl. 1.

#### PLATE III

THE HEAD. A-J, *H. spiniger*. K, *H. ualabati*. A, ♀ from dog, Java, 'aa' head width, 'bb' head length. B, ♀ from dog, Brasil. C, ♂ from dog, Belgian Congo. D, ♂ from *Oncifelis salinarum*, Argentina. E, ♂ from dog, California; type *H. armiferus* Paine. F, ♀ from dog, California; type *H. armiferus* Paine. G, ♂ from coyote, California. H, ♀ from *Oncifelis salinarum*, Argentina. I, ♀ from dog, South Africa; type *M. spiniger* Enderlein. J, ♀ from jackal, Uganda. K, ♂ from "Black Wallaby", Victoria, type *H. macropus* Paine.

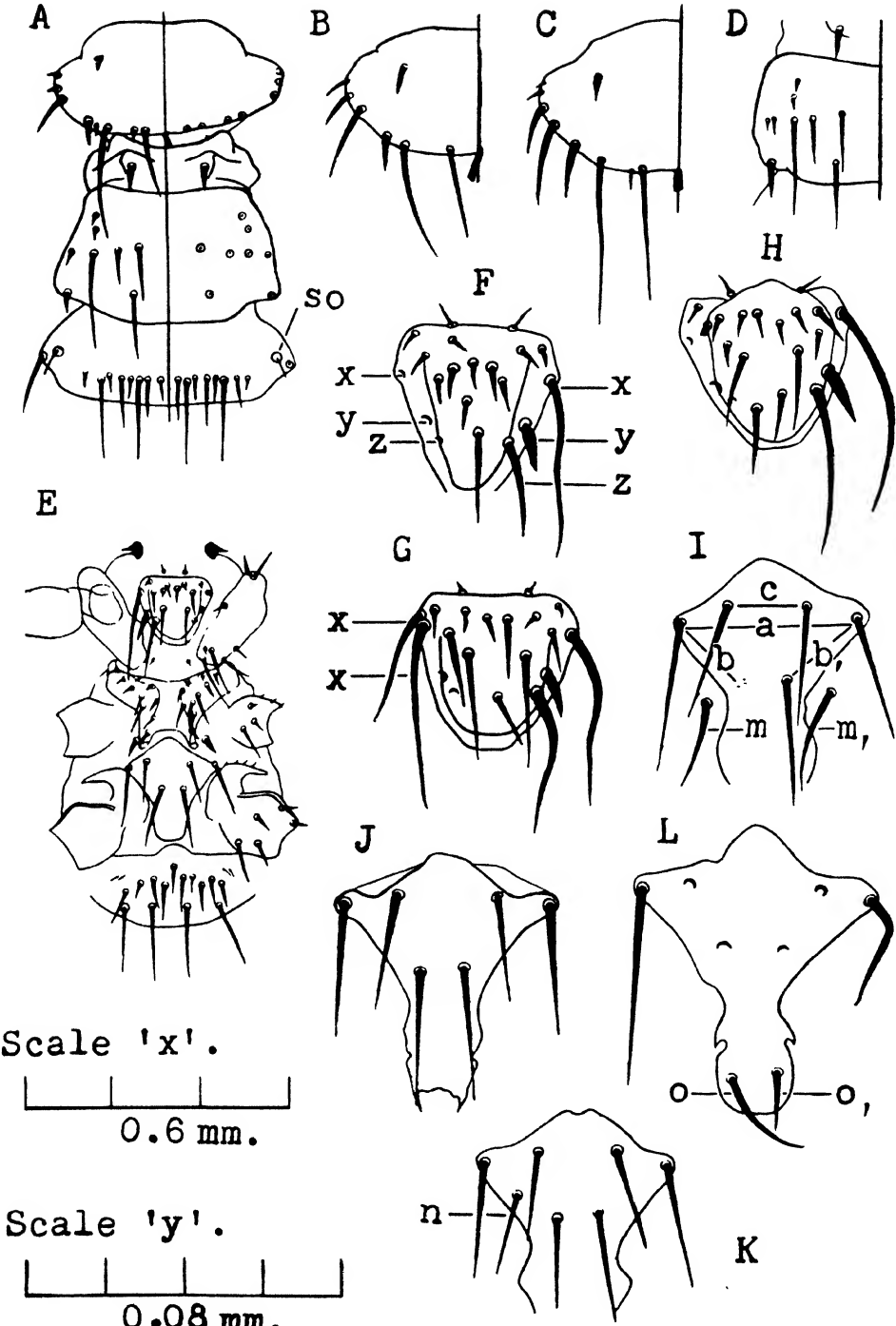
Convention all figures: dorsal to left, ventral to right.



# PLATE IV

THE THORAX. A, thorax from above, with first abdominal tergite, ♀ *H. spiniger*, dog, Java, 'so', sense organ first abdominal tergite. B, first thoracic tergite, ♂ *H. spiniger*, *Oncifelis salinarum*, Argentina. C, first thoracic tergite, ♂ *H. ualabati*, *Wallabia bicolor*. D, third thoracic tergite, ♂ *H. spiniger*, coyote, California. E, thorax from below, with first abdominal sternite, ♀ *H. spiniger*, dog, Java. F-H, plate first thoracic sternite, *H. spiniger*: F, ♀ from jackal, Uganda; 'x', 'y', 'z', three pairs generally occurring setae. G, ♀ from dog, Java; note seta 'x' duplicated on left. H, ♀ from dog, South Africa, type *M. spiniger* Enderlein. I-K, plate third thoracic sternite, *H. spiniger*, L. *H. ualabati*: I, ♀ from dog, South Africa, type *M. spiniger* Enderlein; intersetal distances 'a', 'b' (mean of 'b', 'b'1), 'c': note extra pair of spines 'm', 'm'1, at sides of plate. J, ♂ from dog, Australia. K, ♀ from dog, Java; note extra spine 'n' on plate. L, ♂ from 'Black Wallaby', Victoria, type *H. macropus* Paine; note extra pair of spines 'o', 'o'1, on plate.

Scale: A-E, scale 'x'; F-L, scale 'y'.



# PLATE V

THE ABDOMEN. A, Abdomen, omitting detail of terminal segment, ♀ *H. spiniger*, dog, Brasil; setae other than largest represented by dots for sternites 4, 5; 'so', sense organ; 'sp', spiracle. B-D, terminal abdominal segments, showing setal row, 'sr'. B, ♂ *H. ualabati*. C, ♀ *H. spiniger*. D, ♂ *H. spiniger*. E, external genitalia, with extrovert phallus, ♂ *H. spiniger*. F, phallus, ♂ *H. spiniger*, diagrammatic relief. G, extrovert phallus, ♂ *H. spiniger*. H, extrovert phallus, ♂ *H. ualabati*.

E-H: 'ap', apodemal plate; 'bk', beaklike structure; 'f', flap; 'lp', 'lp1', lateral process; 'p', process; 'ph', phallus; 'pm', paramere; 'r1', 'r2', 'r3', basal, central and distal regions of phallus; 'sc1', 'sc2', sclerotisations strengthening lateral processes, 'sc3', 'sc4', sclerotisations strengthening beaklike structure; 'ss', saclike structure; 'st', spine.

Convention: A-D, dorsal to left, ventral to right; E, from the side; F-H, from below. Scale: A scale 'x'; B-D, scale 'y'; E-H, not to scale.

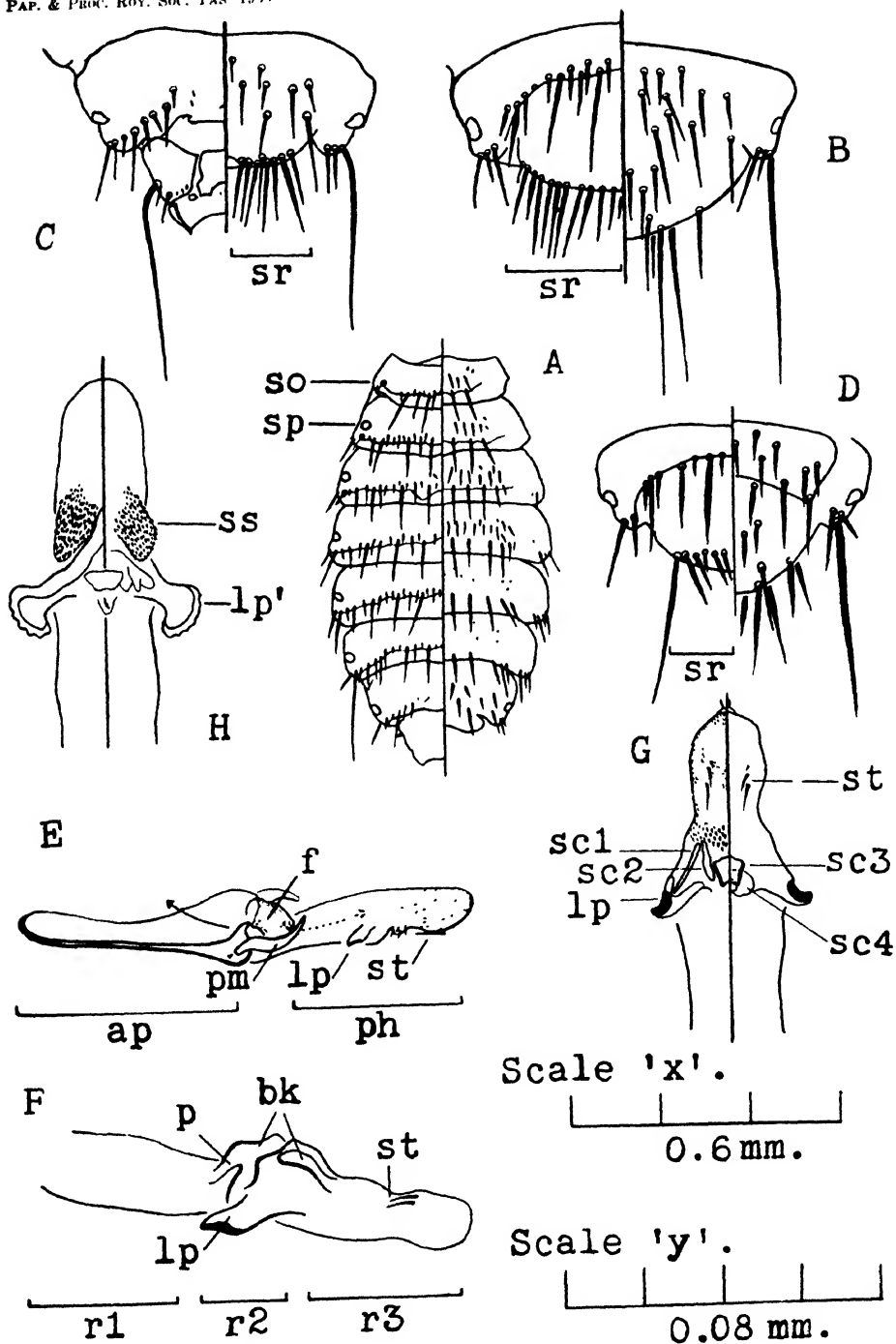




PLATE VI

A, external genitalia *H. ualabati*, in situ. B, external genitalia *H. spiniger*, in situ. C, *Heterodoxus spiniger* (Enderlein) from *Herpalarus salinarum* Thomas, (Argentine, Jujuy, F. L. Werneck ).

A, B: 'ap', apodermal plate, 'b', bar; 'bk', beaklike structure; 'f', flap, 'pm', paramere; 'lp', 'lp1', lateral process, 'ss', saclike structure, 'st', spine.





## The Distribution of *Heterodoxus spiniger* (Enderlein)

By

GORDON B. THOMPSON

(Read 13th November, 1939)

Plomley and Thompson (1937) drew attention to the interesting distribution of *Heterodoxus* on non-marsupial hosts; the present paper consists of the records of distribution and other information relating to the problem. In collecting this information, I have been helped by numerous workers; it would be quite impossible to list them all, but I wish to take this opportunity of thanking them all for their kind co-operation.

### HOST SPECIFICITY

In view of the relationship of the parasite, there can be little doubt that the true hosts of *Heterodoxus spiniger* are Australian marsupials (kangaroos and wallabies); it may be possible to limit the host to a single species or group of very closely-allied species when more extensive collections are available. Host specificity is perhaps more definite in the Mallophaga than in any other group of ectoparasitic arthropods. A species is normally found to be a parasite only of a single host species or group of very closely allied host species. At present we know nothing of the factors controlling host-specificity, but considering the apparent opportunities for the transference of a parasite from one host to another, it is surprising that the establishment of a louse species on a host other than its 'phylogenetic' host does not occur more often. The occurrence and establishment of a parasite on such another host is a phenomenon to which the term *straggling* is applied.

The numerous records of the occurrence of *Heterodoxus spiniger* on the domestic dog show that it is a well-established parasite of this animal, but its haphazard geographical distribution emphasizes that it is a straggler. The records suggest that the straggling has occurred not in the distant past but recently, and that the parasite is becoming more firmly established and more common on its new host rather than waning. The louse does not seem to have been found on non-marsupial hosts until about 1900, while *Trichodectes canis* was described over a hundred years ago. There are no records of *T. canis* having been taken together with *Heterodoxus* off the same dog. I have, however, received specimens of the sucking louse *Linognathus setosus* (Olfers) and the flea *Ctenocephalides canis* (Curtis) taken in company with *H. spiniger* from a dog in Tasmania. It appears that in some parts of the world, e.g. South Africa, *H. spiniger* is the 'normal' parasite of dogs, while *T. canis* is unknown. The occurrence of *H. spiniger* on an ocelot, *Herpailurus salinarum* Thomas, in Argentina is difficult to explain (Werneck

(1936)). Dr. Werneck tells me that there was quite a flourishing colony of the parasite on the animal when it was killed. Its occurrence on the coyote and jackal may be due to the association of the domestic dog with these closely allied forms. Cummings (1913) has recorded *Heterodoxus* from a crow (*Corone australis* = *Corvus coronoides* V. & H.), but the record is probably one of chance straggling, when the bird settled on a dead marsupial or dog to feed.

#### NEW RECORDS

Plomley (1940) has recorded a number of instances of the finding of *Heterodoxus spiniger* on dogs. The following additional records refer to hitherto unpublished instances of the finding of *Heterodoxus* sp. on dogs.

N. California, 1937 (*M. A. Stewart*). California, Madera County, 5. iv. 1932 (*W. L. Jellison*). Oklahoma, Stillwater, 1925. Kansas, Manhattan, 10. ii. 1912 (*J. W. Scott*). Arizona, Phoenix, 1928. Venezuela, Zaraza, 1935. British Guiana, Georgetown, 27. x. 1922. Ecuador, 1930. Haiti, Momance, 1913. Burma, Rangoon, 1931. Uganda, Kampala, iii. 1932 (*G. H. E. Hopkins*). Natal, iii. 1917. Sierra Leone, 3. x. 1925. Union of South Africa, Pretoria (*Dr. Rene du Toit*).

The record from the Canal Zone is of particular interest as a complete count was made of the parasites. The host was a dog, and 96 ♂♂, 122 ♀♀ and 39 immature specimens were collected.

The following notes were sent by the collector of the Javanese specimens:— '*H. longitarsus* (Piaget) is a pest in some cases in Java. The dogs have large bald patches on their backs and the parasites make large bloody, purulent wounds' in which they live in large numbers. One can find blood in the parasite sometimes. I have often found such'. In another letter the same collector states:— 'the dogs with *H. longitarsus* (Piaget) also possess ticks and fleas but no lice. I have collected twenty examples of the parasite from one dog, but I think there were hundreds in the wounds. It is not very pleasant to investigate such dogs.'

Dr. Stewart informs me that some dogs in northern California were recently found to be very heavily infested with *Heterodoxus*. He believes, in the absence of definite data, that this louse is rather common on domestic dogs in northern California. Dr. R. du Toit informs me that *Heterodoxus* is a very common parasite of dogs throughout South Africa.

Until recently the only record of the parasite from India was based on specimens in the Indian Museum collected from domestic dogs in Calcutta and labelled as "*Menopon spiniger*". Additional specimens taken from a dog in Calcutta have recently been received.

On the authority of the Department of Agriculture of the Philippine Islands at Manila, the parasite is unknown in the islands. In the United States National Museum, however, there is a single specimen collected from a man, Phillipine Is., Victorias Oc. Negros, 1930. This record makes the second instance of the occurrence of *Heterodoxus* on man. I think on the evidence of the single specimens recorded in each case that the occurrence of this parasite on man may be regarded as accidental; the close association of man with the dog must always be remembered.

<sup>1</sup> According to this collector, numerous ticks (*Amblyomma* sp.) were found on the dogs in company with the lice and it must be borne in mind that the lice may have taken up their positions at points where ticks had previously attached themselves.

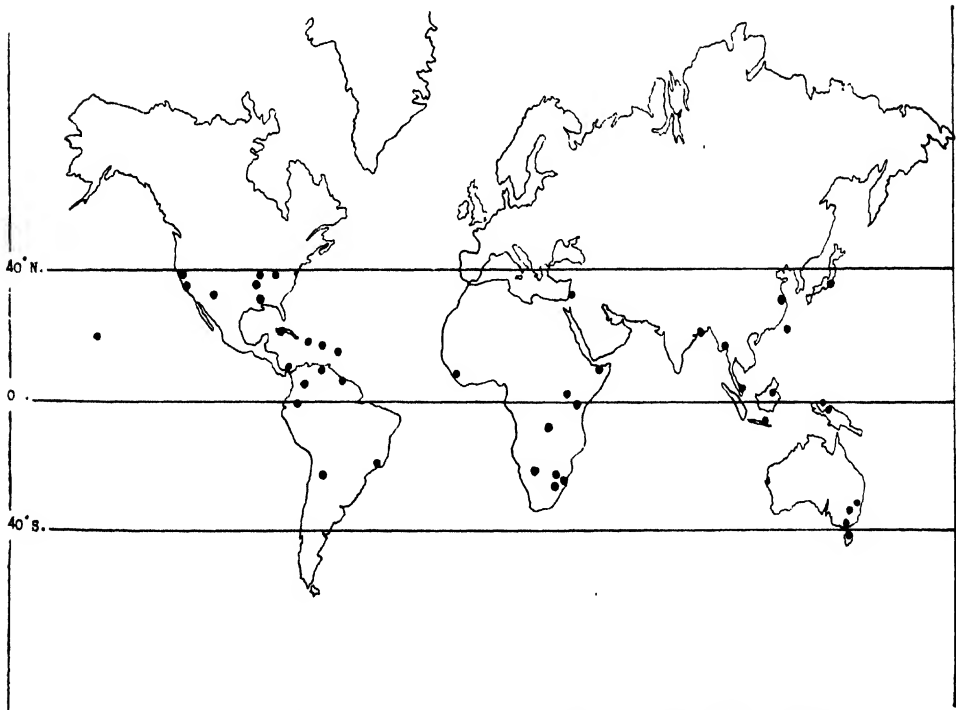
## ABSENCE OF THE PARASITE FROM VARIOUS PARTS OF THE WORLD

In the course of collecting together the distributional data of this parasite, certain workers were kind enough to supply definite evidence of its absence. As these are of interest the areas are listed below, together with the correspondents' comments.

Mauritius, Ceylon, New Zealand, Fiji Islands, Trinidad, Jamaica (1), Gold Coast (2), Nigeria (3), British Somaliland (4), Canada, Europe, U.S.S.R., Cyprus, China (Shantung), Iran.

- (1) 'I have never found any lice on dogs in Jamaica. The dog in Jamaica has probably been protected by the prohibition against their importation from all countries except the British Isles. This regulation has been in force for 30-35 years.'
- (2) 'No lice have ever been found on dogs in the Gold Coast.'
- (3) 'No lice seen on dogs during fifteen years in Nigeria.'
- (4) ' . . . . . in this Mohamedan country there are virtually no dogs except a few European owned animals and I have not so far encountered lice on dogs here.'

In Ceylon, Fiji Islands, and Canada only *T. canis* has been observed; I have recently seen specimens of this louse taken from a dog in New Britain, Kieta District, 16. x. 1937. There is reliable evidence that *T. canis* does not occur in the remainder of the regions listed above.



Map to show records of distribution of *Heterodoxus* on the dog, together with those of distribution on *Herpailurus salinarum*, coyote and jackal. Records from all sources.

## GEOGRAPHICAL DISTRIBUTION OF THE PARASITE

On the accompanying map of the world, I have indicated the places from which *Heterodoxus* (almost certainly *H. spiniger* in all instances) has now been reported from non-marsupial hosts, and it is interesting that all the localities are within the area confined between lat. 40°N. and lat. 40°S., or very nearly.

The distribution of a louse is normally controlled by its host but it appears that the controlling factor in the present case may be climatic. If this distribution is as real as it appears from the records to date, it may throw some light on a feature of parasitism concerning which we know very little. It may be that as a result of the parasite having adapted itself to a new and 'non-phylogenetic' host, other factors have come into force. Van Volkenberg (1936) suggests climatic factors to explain the absence from Porto Rico of certain parasites of imported hosts (domestic animals).

## TRANSFER TO NEW HOSTS

How this biting louse became a parasite of the domestic dog, is difficult to say. Three possibilities present themselves. First, since the true hosts (i.e. kangaroos and wallabies) of this louse are, I understand, fairly easy animals to keep in zoological gardens, the parasite may have become transferred to dogs as a result of contact with these marsupials, in the various part of the world to which they have been transported (Ewing (1933)). Yet, zoological gardens are very much more common in those regions where the parasite has not yet been recorded!

Secondly, in the past when settlers arrived in Australia with their dogs, the marsupial hosts were much more common than they are to-day, and the dogs may have acquired the lice from hunted marsupials; having established itself on dogs in Australia it became distributed by the dogs when accompanying man on his voyages to other parts of the world. Yet, the parasite does not seem to be common on non-marsupial hosts in Australia, and moreover, few dogs, if any, are exported from Australia!

Thirdly, it is common for ships to carry pet dogs and equally so for ships visiting a foreign port to take away with them some animal peculiar to the country visited; many ships visiting Australia would take away with them a kangaroo or wallaby, these animals being probably the most readily obtainable 'curiosity', and a very well-known one outside Australia. Here then is a possible link between the dog and the marsupial, and it is noteworthy that the parasite has been reported from most of the important seaports between the parallels of 40° N. latitude and 40° S. latitude.

## REFERENCES

- BEDFORD, G. A. H., 1919.—Anoplura from South-African hosts. *6th & 7th Rept. Vet. Res. S. Afr.* p. 718.
- BODENHEIMER, F. S., 1937 *Prodromus faunae palestinae* . . . . . *Mém. Inst. Egypte.* XXXIII p. 230.
- CUMMINGS, B. F., 1913.—On some nondescript Anoplura and Mallophaga. *Bull. ent. Res.* IV. p. 44.
- EWING, H. E., 1931.—(Report). *J. Parasit.* XVII. pp. 56-57.
- , 1933.—Some peculiar relationships between ectoparasites and their hosts. *Amer. Nat.* LXVII. p. 370.

- FRENCH, C., 1934 —(Exhibit) *Vict. Nat.* XLI p. 11
- KELLOGG, V. L., 1914.—Ectoparasites of mammals *Amer. Nat.* XLVIII p. 262
- AND FERRIS, G. F., 1915 The Anoplura and Mallophaga of North American mammals  
*Leland Stant. Univ. Pub. Univ. Ser.* p. 67
- PLOMLEY, N. J. R., 1940 - Notes on the systematics of two species of *Heterodoros* (Mallophaga,  
Boopidae). *Pap. Roy. Soc. Tasm.* 1939 (1940), p. 19
- AND THOMPSON, G. B., 1937 —Distribution of the biting-louse *Nature*, CXL,  
p. 199
- ROBERTS, F. H. S., 1935.—A check-list of the arthropod parasites of domesticated animals in Queens-  
land *Aust. Vet. J.* XI pp. 6-7
- THOMPSON, G. B. 1936. Mallophaga on a bird's egg *Ent. mon. Mag.* LXXII, p. 95
- UCHIDA, T., 1926. Studies on Amblycerous Mallophaga of Japan *J. Coll. Agri. Tokyo* IX,  
pp. 1, 6
- VAN VOLKENBERG, H. L. 1936 - *Rep. P.R. Exp. Sta.* (1935) p. 23





## Geology of the Tyenna Valley

By

A. N. LEWIS, LL.D.

(Read 13th November, 1939)

### PLATES VII-X

The field work which has resulted in the collection of the data here set out was undertaken in the first place in an endeavour to find a definite floor of the permian sedimentary sequence in order to measure the vertical succession, a search which has now been prosecuted by the writer over the whole island, without success. In the course of this investigation some remains of trilobites were found in rocks previously mapped as permo-carboniferous. This find rendered desirable a further investigation into the stratigraphical position and relationship of these beds and has lead to the discoveries here recorded.

The Tyenna Valley is the area with the easiest access from Hobart where lower palaeozoic rocks outcrop and is a junction area between the dolerite capped plateaux of the centre and south-east and the older rocks of the western mining fields. Such areas are vital to the interpretation of the sequence of geological events in Tasmania and the one here described is the most readily accessible of such areas. Further, the neighbouring areas of Adamsfield to the west, the Mt. Anne and the Weld River Valley to the south-west, Mt. Field Plateau to the east and the Florentine Valley to the north have already been the subject of more or less detailed geological investigation. The district described here abuts on those areas and provides an essential connection without which the accounts already published are deficient in scope.

The field work was carried out during the Christmas holidays of 1937 and 1938 and the Easter holidays of 1938 with several day trips to the trilobite beds at Juneec.

The writer was accompanied on the first two trips by Mr. B. Koch and on the last by Mr. W. A. Tate. He was also accompanied to the tribolite beds by Dr. F. W. Whitehouse. He desires to express his appreciation of the assistance rendered by these gentlemen. He also records with thanks the assistance given by Mr. J. F. N. Murray in the drafting of the plans and sections accompanying this report.

### PREVIOUS LITERATURE AND HISTORY

Thirty years ago W. H. Twelvetrees (1908, 1909), Government Geologist, published two very brief accounts of this area, with sketch maps. These were

compiled for the special purpose of enabling the government of the day to consider the extent of the concessions being asked by the Great Western Railway Company. Although still valuable and of great use, many of Twelvetrees' conclusions must now be revised in the light of more recent field work.

T. Stephens (1910) contributed a brief paper to the Royal Society of Tasmania describing certain features near Glenora, but this is of little use today beyond a record of actual field observations along a limited line.

A. McIntosh Reid (1921), a former Government Geologist, mentions this area briefly in his *Osmiridium* in Tasmania. His map (*ibid.* Plate X) is valuable and as far as it goes is much in advance of Twelvetrees' sketch but the scope of Reid's work limited the text to a very general reference to the area discussed in this paper.

In 1902 T. Stephens discovered some trilobite remains on the flanks of Tim Shea in the Florentine Valley. Unfortunately, he did not himself describe the locality or stratigraphic relationships of his find which have, until now, remained a mystery to Tasmanian geologists. The palaeontological significance of this find was recorded by R. Etheridge Jun. (1904).

The adjoining areas have been surveyed or briefly described:—

In 1921 Loftus Hills reported on the geology of a small section of the Florentine Valley from the point of view of its suitability for water conservation and dam sites. His report has not been published but is available for inspection at the Mines Office, Hobart. The area covered by Hills abuts to the north on the district dealt with in this account but many of Hills' conclusions as to the geological structure of the country towards Junee— i.e. south of the area on which he was reporting must be revised in the light of fuller investigation.

In 1922-1923 the present writer described the topography of the upper levels of the Mt. Field Plateau which lies to the east and north of the area here described. In 1924 a further paper was published comprising a general description of the Mt. Anne district, Weld River Valley and southern slopes of Mt. Mueller. This area lies to the south-west of the area here described and abuts on to it.

P. B. Nye (1929) contributed a very comprehensive account of the Adamsfield District to the north-west of the area here described with an excellent map. This account is the most detailed survey of any area in South Western Tasmania yet published.

Reference need only be made to Mr. Nye's Bulletin on the Adamsfield District (1929, pp. 2-4) for an account of the history of mining in the district. Access to the area described by Nye was through the district here described. During a lengthy period extending from 1885, or thereabouts, to 1909, the Tyenna Valley was thoroughly investigated by prospectors many of whose workings are still discernable in the regrowth forests.

The following changes in Twelvetrees' place names may here be noted to avoid confusion:

'Roll's Selection' is now Junee township.

'Rumney's Selection' is now owned by Jeffreys.

'Lord's Selection' is now known as Maynes', the name of a former owner, but it has recently been acquired by the Kallista Timber Development Co. Pty. Ltd. Kallista mill, now burnt out, stood on the eastern boundary of Mayne's farm and the Kallista Railway station is located a little west of Rumney's Selection (now Jeffrey's).

The township of Tyenna has dwindled in importance and Fitzgerald, some two miles further west, with the contiguous township of Juneë, have become the more important centre in the valley. With these exceptions Twelvvetrees' place names still stand. The Adamsfield pack track follows, with a few deviations, the Great Western Railway pack track as sketched by Twelvvetrees.

'High Rocky' of Twelvvetrees is called by its official name, Mt. Mueller in this account. The name 'Mt. Stephens', is replaced, in accordance with universal usage by 'Tim Shea'. The former name was not bestowed in honour of the late Mr. Thomas Stephens in which case it should have been retained, but dates from a far earlier period.

'Mt. Humboldt' was changed to Mt. Field West in 1918. Humboldt, a name bestowed in honour of a famous scientist, by Strzelecki should now be restored. It has been so restored here and the name 'Mt. Field' used for Mt. Field East.

The names 'Tyenna Valley' and 'Tyenna River' are used in place of 'Russell Falls River'. Both names are in accordance with official cartography but Russell Falls River is an unfortunate choice as it does not flow over Russell Falls and we have a Russell River (a tributary of the Huon, rising in the vicinity) and a Russell Falls Creek.

#### GEOGRAPHY AND PHYSIOGRAPHY

The area here described comprises the Tyenna valley from its source on Mt. Mueller and neighbouring ranges to its confluence with the Derwent and extends to the divide between the Tyenna River and the Florentine River constituted by Mt. Mueller, The Needles, Tim Shea, Wherretts Look-Out and the Mt. Humboldt-Tyenna Peak Range, together with a brief description of the northern and north western slopes of that divide and portion of the Florentine Valley sufficient to connect it with the area described by Nye in his bulletin on the Adamsfield district. This area has a total length from east to west of about 25 miles and from north to south of about 10 miles.

The district is reached by rail and a first class road from Hobart via the Derwent Valley. Fitzgerald is some 54 miles distant from Hobart by road and rail. From Fitzgerald a good motor road extends to Juneë and thence a fair road has been constructed westward to Kallista (4 miles) and another good road north-westward across the Tyenna and Juneë Rivers to Storey's farm 3 miles west of Juneë. From Kallista a rough road, passable with difficulty by cars, extends to Maynes (2 miles). Thence the Port Davey track, now in an almost impassable condition, extends through the area to the south of Mt. Mueller. From Storey's a first class pack track extends through the area to Adamsfield via Tim Shea-Wherretts Look Out saddle and the upper Florentine bridge. In recent years the Forestry Department has cut numerous tracks through the forest. These, at present, give several lines of access to the Styx valley and to the Needles-Tim Shea ridges. The old Mt. Humboldt Mine track from Kallista to the Needles-Tim Shea saddle is still passable on foot with some difficulty. In general, the area has been well opened up since Twelvvetrees reported on it and although still mostly covered with dense rain forest, access is possible, although often with difficulty, to any part.

The country covered by this account is the wide forest-covered basin which lies at the head of the Tyenna Valley with its bounding ridges. This area is bounded on the north by the Mt. Field Plateau, particularly that portion known as Tyenna Peak, Mt. Mawson and Mt. Field East (Lewis, 1922) and to the west

by Mt. Mueller (Lewis, 1924). These two mountain masses are joined by a long ridge varying in elevation from 1900 feet to 3500 feet and formed by Wherretts Look-out, Tim Shea and the Needles. To the south, the area is bounded by the Maydena Range, which runs eastward from Mt. Mueller at an average elevation of 2000 feet and forms a rocky divide between the Tyenna Valley, and the Styx valley. To the eastward the area slopes gradually to the Derwent at Glenora. The head of the valley is a broad expanse of rain-forest covering numerous mountain spurs but of relatively open topography, some 10 miles across both from north to south and east to west, with a few steep-sided minor hills rising from the lower levels at 1000 feet to an average height of 1500 feet, and a ring of steep mountain slopes around the circumference rising to 4000 feet and over, in places. Further east, between Fitzgerald and Westerway, the valley becomes a gorge with steep and rocky, although forest covered, sides between the spurs of Mt. Field to the north and Marriott's Look-out at the end of the Maydena Range to the south.

Looked at from the purely topographical point of view, the area is a normal valley drained by a river originating in many small tributaries which rise in a semi-circle of high mountains and, after collecting these streams into one channel, flowing through a gorge to join the main river, the Derwent. Looked at from a purely geological point of view the area consists of normal permian-triassic sedimentary rocks with intrusive dolerite towards the east and west and in the higher altitudes and with a block of ordovician sedimentary rocks occupying the central or more open portion. When, however, the present physiography is considered in relation to the geological structure and history a surprising succession of contrasts is presented which force us to certain conclusions with a very definite bearing on the general structural framework of southern Tasmania.

### GEOLOGY

This area shows a range of rocks within a few miles which in itself makes the locality of particular interest. The most extensive group of rocks represented is of ordovician age, perhaps with an upper cambrian base, and consisting of slates, quartzite-conglomerates, mudstones and limestones. This group is well represented in the central portion of the area. It is also possible that some of the devonian intrusive basic rocks or serpentines are to be found. The later lower palaeozoic series from the West Coast Range conglomerate series upwards to the various series assigned to the silurian period have not yet been identified although they occur further west at Adamsfield (Nye, 1929). A second important sedimentary group, extending from the permian tillite to the upper coal measures of triassic age with its intrusive dolerite is very completely represented both in the eastern and the western portion of the area. Pleistocene glacial deposits occur at higher altitudes and pleistocene to recent river deposits at the lower levels with late tertiary basalt in the extreme east of the area.

### Structural Geology

It will be useful to describe area by localities before attempting to give any general summary of the geology as a whole. The area can be naturally divided into a number of major blocks as under.

#### *A. Glenora-Westerway*

The Derwent flows down a valley which is primarily due to faulting movements in pliocene-pleistocene times. It is marked by long parallel fault lines running roughly north and south, parallel to the general course of the river but crossed

repeatedly by the actual bed in its many bends. At Glenora, the Derwent with its tributary, the Tyenna River flows over a depressed block the eastern boundary of which is probably the fault running from the east coast of Bruny along the slopes of Mt. Wellington, Mt. Faulkner, Mt. Dromedary and Platform Peak. This block appears to have been slightly tilted to the westward, with permian limestones which appear at the fault line mentioned above in the Broadmarsh-Pelham Valley forming the eastern boundary of the block. The dip of the block brings the higher Ross sandstones and triassic coal measures down to the river level (100 feet above sea level) at the western edge of the block, the eastern boundary of the area described in this paper. Another major fault runs approximately parallel to the first mentioned fault and, subject to erosion details, forms the western boundary of the present Derwent Valley. This fault brings harder permian mudstones into sharp juxtaposition with the soft triassic coal measures and the Derwent has eroded its valley in the latter near the junction. It is flowing, in general terms, at right angles to the dip of the block of softer rocks and has edged over to the lowest point of the tilted block until its further erosion westward was impeded by the harder rocks west of the fault, although the still more resistant dolerite intruding the softer Ross sandstones and coal measures and also the more recent basalt flows have diverted the actual river course to a minor degree in many places and have been the final control regulating the actual course of the river as now seen.

The fault which brings the permian mudstone to the level of the triassic sandstone, is, as so usual in this country, rather a zone of converging faults than a clean break. This zone extends for some six miles in the valley of the Tyenna river. It is described by Stephens (1910, p. 172) although the significance of these features was not recognised at the time he wrote. From an analogy with similar fan-fault zones near Hobart, I postulate that the north-south fault meets one running roughly east-west along or parallel to the Tyenna valley in this vicinity. The north-south fault which may be termed the Ellendale fault constitutes the eastern boundary of the Mt. Field Plateau. It runs between Mt. Fenton and the lower spurs of the Mt. Field East, somewhat to the west of Fentonbury and Ellendale, and crosses the road to Dunrobin Bridge on the hill to the north of Ellendale. A minor fault forms the eastern edge of the disturbed area crossing the Tyenna valley a couple of miles east of Westerway and brings permian mudstone into juxtaposition with dolerite intrusive into Ross sandstone which form the rock of the Derwent Valley further east.

#### *B. National Park-Fitzgerald*

From about a mile east of National Park township westwards to Juneë a normal sequence of upper permian-lower triassic rocks is to be seen somewhat broken by minor faults. In this distance the level of the river bed rises from 500 feet to 900 feet above the sea level. The strata have a slight dip to the westward (up stream). The base of the Ross sandstone appears at approximately the 900-foot contour. This is considerably lower than is usual and indicates the possibility of one or more small step faults parallel to the Tyenna Valley.

Between Fitzgerald and Juneë, Ross sandstone occupies the bottom of the valley (approximately 900 feet) succeeding the permian mudstone without any marked unconformity. In this area a number of small faults at right angles to the main river valley are apparent in the road and railway cuttings but these are not of sufficient magnitude to replace the triassic strata by that of any other age. These faults, or some of them, appear to be responsible for the main topographical features of the Mt. Field Plateau already described (Lewis, 1922)

and of the Maydena Range to the south. The Maydena Range corresponds stratigraphically approximately with the Mt. Field Plateau but appears to have a much thinner cap of dolerite, which in at least one saddle south-east of Fitzgerald, is missing altogether, Ross sandstone extending to the summit of the range.

Between National Park township and Westerway the Russell Falls River flows across a bar of dolerite some 3 miles wide. It has cut through this to a depth of several hundred feet and is still cutting. This has resulted in the formation of a steep sided gorge which also constitutes a physiographic control for the higher reaches of the river, present erosion depending on the rate which the river is able to cut through the dolerite here. Above this gorge the valley is more open. The dolerite here appears to be at least 1000 feet in thickness.

A crushed zone is apparent in the permian mudstone of the valley floor on both sides of National Park township. Just west of the township the dip of the strata is  $20^{\circ}$  to the south-west. North of the river at the Park entrance the dip is  $1-2^{\circ}$  to north. About  $\frac{1}{2}$  mile east of National Park railway station the varying tilt clearly indicates the fault zone—the dip within 200 yards is  $10^{\circ}$  to south-west,  $75^{\circ}$  to north-west and  $10^{\circ}$  to south-east. In fact, this area is really a broken pressure fold. A major east-west fault along the present course of the river is apparent with slight over-thrusting from the south east. A north-south fault running just east of Russell Falls is also indicated.

The fault which is responsible for the Lake Fenton-Broad River valleys (Lewis, 1922) is apparent in the valley at Arcadia and a further fault, responsible for the Lake Belton-Belcher and Lake Hayes valley can be seen crossing the bottom of the valley about one mile west of Fitzgerald railway station whence it runs up the considerable valley of the Humboldt Rivulet entering the Tyenna River from the north. This fault is continued southwards up a corresponding but smaller re-entrant on the Maydena Range. These faults have only a small throw, difficult to measure owing to the absence of any identifiable key strata but the writer estimates the average throw at 200-500 feet.

### *C. Junee*

Junee is the site, in the valley bottom, of the junction between lower and upper palaeozoic rocks. Unfortunately, the two great groups of rocks are, in every place where an inspection is possible, faulted against each other and no vertical succession is available for study.

Upper permian mudstone outcrops in the river bed at Fitzgerald railway station. Fifty feet or so higher up the valley side, it is succeeded by Ross sandstone which reaches the river bed, in the natural course of the prevailing slight westerly dip, about half a mile west of Fitzgerald although the actual junction in the river is obscured by recent alluvium. A major tectonic fault running approximately north and south cuts the valley near Junee railway station. This break is also obscured by alluvium but it appears to run from the Humboldt rivulet valley north east of Junee, southward a few hundred yards east of the road through Junee township and the prolongation of this road southward up the slopes of the Maydena range. A second fault runs from the middle of Junee township south-westward, just touching the Fitzgerald-Kallista road where that road crosses the spur between Junee and Pillingers Creek. The first mentioned is here called the Junee fault and the second the Roberts fault. A third fault runs down the valley of the main branch of the Tyenna River. The last mentioned fault is the same feature which has already been mentioned at National Park and is the main factor governing the valley topography. It is probably really a complicated

fault zone with many ramifications but the main river appears to follow one very marked break near the centre of this zone.

East of the Junee fault, Ross sandstone occupies both sides of the valley to a considerable height—showing a thickness of, perhaps 1000 feet, although allowance must be made for small unidentified faults running parallel with the valley. West of the Junee fault on the north of the valley blue limestone of the Junee series outcrops. In the bottom of the valley white quartzite appears from below the limestone. About a mile south of the river beds of blue Junee limestone again appear on the west of the fault. Between this latter limestone and the Roberts fault and the Junee fault occurs a wedge of permo-carboniferous sandstone, here called the Roberts sandstone as it covers practically entirely the farm owned by Mr. George Roberts. The spur between the Roberts fault and the Tyenna River is occupied by contorted yellow mudstones of the Junee series in which trilobite remains have been found. This bed ends abruptly at the river where the main east-west fault line brings white quartzite to the surface. The Roberts sandstone only extends at most  $\frac{1}{2}$  a mile south of the Junee Kallista road where it abuts on Junee Limestone at 1450 feet. This limestone skirts the hills south of Mr. Roberts farm and appears in the valley of Pillinger Creek from the Junee fault to the Roberts fault. Here it is cut off by the Pillinger fault west of which white quartzite of the Pine Hill block stands from river level (1000 feet) to 1450 feet. A mile and a half further south the main uplift of the Maydena range brings Ross sandstone again to the surface and this rock with its overlying intrusive silt of dolerite occupies the flank of the range from about 1450 feet to the summit at about 2500 feet. North of the river, at the Junee bridge there is some blue limestone. A few hundred yards along the road to Junee Cave, the yellow mudstone of the Junee series outcrops from below the blue limestone indicating a small fault just west of the ridge which runs southward to Junee bridge. The limestone appears at Junee cave and Storeys at an elevation of about 150 feet above Junee bridge.

The Roberts sandstone is a peculiar rock unlike any of the permian sequence as yet seen by the writer. Its nearest affinity is the fossiliferous marine sandstone at the top of the Preolenna coal measures but this analogy must not be pushed too far. It consists for the most part of coarse friable sandstone of a deep yellow to reddish colour merging into grits. Some layers are highly fossiliferous, consisting largely of stenopera and spirifera casts with many avicula pectens but these fossil bands do not lose the gritty nature of the bulk of the section. Fossil layers are to be seen on the road to Mr. Roberts house a few yards south of the Junee-Kallista road where the latter crosses the saddle between Junee and Pillinger Creek. Between the 1250 feet-1300 feet contours there are carbonaceous bands with numerous impressions of plant stems and it is possible that a search would reveal some small coal seams. Above 1400 feet the sandstones closely resemble the coarse members of the Ross series. These rocks extend to the southern extension of the road through Junee and masses of permian fossils are there found at 1250 feet. The red soil mentioned by Twelvetreves as occurring in this vicinity and considered by him to be evidence of basalt is the result of the decomposition of this sandstone. No basalt could be found.

This wedge of permian rocks abuts to the south and west on Junee limestone and is cut off to the east by the Junee fault. Its occurrence is a complete anomaly. It is a rock which does not exactly correspond with any in the southern Tasmanian permian sequence nor with exposures on the flanks of Mt. Mueller further west. Two explanations are possible. This sandstone may be a permian stage lower



than any hitherto observed and faulted into its present position by pressure induced by the earth movements which resulted in the Junee and other faults. If this were the case, it is strange that it is not exposed elsewhere. The lowest members of the permian sequence observable elsewhere in the area are barren slaty grey mudstones. The other alternative is that this is a bed corresponding more or less with the Cygnet and Preolenna coal measures which elsewhere has been removed from above the barren yellow mudstones of the Lindisfarne stage by erosion prior to the deposition of the Ross Sandstone, a possibility recognised by Mr. A. H. Voisey (1938). If this is true the rocks in question may have been protected by neighbouring hills of Junee limestone protruding through the sediments at the close of the permian depositions. This small section may thus prove an interesting factor in the correlation of the permian-triassic system.

On the railway from Junee to Kallista about a mile and a half west of Junee are two small cuttings in a yellowish mudstone—previously mapped by Twelvrees and Reid as permo-carboniferous, quite understandable in the absence of good exposures prior to the construction of the Kallista railway extension. The more easterly of these cuttings is a perfect anticline, pitching at 30° to the north-west. The more westerly cutting is through a truncated anticline, only the easterly limb of which is exposed. This limb is dipping at 80° to the north-east. The strike of both anticlines is approximately parallel in a south easterly-north westerly direction. The rock here is a bed of relatively soft but tough mudstone, light yellow to buff in colour and closely resembling the uppermost permian mudstones in general appearance. The rock in the eastern cutting possess a silky, almost schistose or talcy lustre in sections parallel to the bedding planes and is a mass of fossils, too imperfectly preserved for identification but either worm or shell tracks, coral or algae impressions or cephalopods, or probably, all three, with occasionally fragmentary pieces of trilobite in the more sandy layers and with one very soft sandy layer full of fragments of trilobites. The rock in the western cutting presents the features of a drag fold and a band of white quartzite with a further band of very hard ferruginous sandstone quartzite of dull reddish colour forming the extreme western layer of the series is obviously the resistant layer which has been dragged over and crumpled the softer mudstone of the core of the anticline. That mudstone is tough but very highly weathered and showing little metamorphic change. In fact, it is surprisingly like the permian mudstone and was only identified by the chance discovery of a fragment of a trilobite. In the more westerly railway cutting were found a few layers, only a couple of inches thick and now standing nearly vertical and very weathered, rich in poorly preserved fossil remains. Included in these were some fragments of trilobites. The fossil suite has yet to be described but it provides a horizon which is capable of recognition through the area from Junee to the Florentine and the key to the stratigraphical succession in this area.

North of the river, white quartzite outcrops. This dips in a northerly direction at a low angle. On the road between Junee township and Storey's the white quartzite is succeeded by yellow mudstones mentioned earlier. These are slightly folded and are easily identifiable as the same series as that in the two railway cuttings although no positively identifiable fossils were found. It is difficult to determine the inter-relationship of the strata forming the two cuttings as only the top of the anticlines are exposed and these are separated by several hundreds of yards of soil and alluvium without exposures of rock. However, from observations elsewhere, it is clear that the two rock types observable in these two cuttings are in very close association. Probably the silky micaceous mudstone of the eastern

cutting immediately underlies the more sandy yellow mudstone of the western cutting. That appears to be the relationship at Sunshine Spur and Tim Shea but it is possible that both types are interbedded. The relationship between the limestone and the mudstone is not discernable in Pillinger's Creek although it appears as if the limestone south of the Junea-Kallista road forms the western limb of the anticline cut by the railway cutting, thus showing the mudstone as underlying the limestone. Between Junea township and Junea Cave the limestone can be seen definitely overlying the mudstone outcropping on the road. (See Twelvetreets, 1908, for a description of Junea Cave and the limestone in the vicinity).

Twelvetreets refers to an accumulation of dolerite boulders apparent west of the Junea river and extending for about a mile over Storey's farm and along the Adamsfield track. The present writer can add little to what Twelvetreets has already recorded. These may be the remnants of an old river terrace. Landslips cannot be ruled out as an explanation particularly as a fault is apparent probably running from west of Tyenna Peak to the vicinity of Storeys and indicated by the white quartzite uplifted a few hundred feet above the limestone and forming Sunshine Spur three miles north west of Storeys. Boulders of sandstone amongst the dolerite lend colour to this explanation. A third explanation is possible—namely, that above the limestone and between that rock and the overlying permian mudstone there occurs a sill of dolerite. In two other localities (Chrisp's and Wherrett's Look-out to be mentioned later) the limestone is broken by faults resulting in uplifts westward. In each case there are similar accumulations of boulders and it is quite possible that a sill of dolerite of small thickness has intruded between the lower and upper palaeozoic systems as had occurred between the granite and marine mudstone on the north shore of Reidle Bay, Maria Island. This point is worth further investigation and should be borne in mind in future examinations of areas when this limestone occurs, although the dolerite boulders are only noticeable close to the dolerite of the Mt. Field Plateau.

#### *D. Pine Hill*

At Kallista, a steep-flanked whaleback hill of hard white quartzite stands bare of trees for 400 feet above the surrounding forest. This is known as Pine Hill from a forest of celery top pine which once covered it. It is a crush zone of white quartzite and conglomerate heavily mineralized with haemitite and pyrites. The axis of the hill runs a little south of east and north of west and is also the axis of a considerable anticline which has also been crushed into folds approximately at right angles to the main axis. No rock other than ordovician quartzite and its associates is apparent for the whole 500 feet exposed from the summit to the bed of the branch of the Tyenna River which cuts a small gorge round the north western end of Pine Hill. Twelvetreets (1908) first described the rocks of this area as permo-carboniferous but subsequently (1909) expressed some doubts and Reid correctly mapped them as cambro-ordovician. The 'arkose grits' mentioned by Twelvetreets are really the outcrops of the crushed zone in the core of the anticline which are highly impregnated with iron and might be termed a haemitite quartzite. In the lower levels this is replaced by white quartzite very heavily impregnated with pyrites. In fact, the whole ridge of the hill shows promising prospects of mineral impregnation which might indicate an ore body at some depth. It has been prospected almost all over and small excavations are to be seen everywhere. All appear to yield scattered, very low-grade haemitite and pyrite impregnations but nothing payable has been found to date. However, for practicable purposes the surface has only been scratched. Pine Hill to the south of the valley and Sunshine Spur to the north both indicate the intense folding

processes to which this area has been subjected but no necessary connections between the two occurrences is apparent.

The Pine Hill quartzites and conglomerate extend south eastwards for 2-3 miles to the northern side of Pillingers Creek where they have been eroded into a number of sharp hills standing 300-400 feet above the creek bed. No material change in nature or structure is apparent throughout although local variations from white to pink quartzites and to conglomerates are marked. The Pine Hill quartzites are to be correlated with similar rock at Sunshine Spur and the tops of Tim Shea and the Needles and extend with many fault breaks to the foot of those mountains. The evidence elsewhere shows that the quartzite directly underlies the trilobite bearing mudstone. This relationship is obscure at Pine Hill except at the old Kallista Mill where the quartzites dip at a very high angle under mudstones with a similar dip and strike. Pine Hill is a crushed zone arched into an anticline from which the overlying mudstones and limestones have been removed by erosion. Dr. F. W. Whitehouse found some specimens of *orthis* just at Kallista railway siding.

#### *E. Maynes' Farm*

This area is 'Lords Selection' mentioned by Twelvetrees. At the old Kallista Mill and extending southward and westward for a mile or so are beds of the Junee mudstone, some 200 feet in thickness. At Maynes' there is an area of rich red soil. No outcrops are visible but in a prospect hole some 10 feet deep at the entrance of the Port Davey track some very decomposed rock was found. Twelvetrees considered that the soil indicated tertiary basalt but only identified the rock from the soil. Reid mapped it as tertiary basalt, i.e. corresponding to the flows at Glenora. It may be the top of an eroded plug but from my examinations of the decomposed rock I am of the opinion that this is a small occurrence of serpentine of the black variety as described by Nye (1929, p. 15) at Adamsfield. No specimen sufficiently fresh to make an authoritative examination could be obtained in spite of much digging but the resemblance with weathered portions of the dyke east of Adamsfield is very close and significant. As similar serpentine is now being quarried at Adamsfield for osmiridium this point is worth further examination by the Geological Survey.

From the top of the clearing at Maynes' Farm to the first branch of Fourteen Mile Creek on the Port Davey Track, about three miles, the rock is quartzite conglomerate resembling that at the top of Pine Hill. Apparently the conglomerate quartzite succeeds the sand-quartzite in all the outcrops in the area. This quartzite is at least 200 feet in vertical depth here but no accurate measurement of the dip and strike was possible. No limestone is apparent west of Pine Hill. Probably a fault runs immediately west of the clearing at Maynes', that is, separating the mudstone and serpentine from the quartzite and the quartzite is another anticline similar to the one forming Pine Hill and striking approximately parallel although on a bearing somewhat nearer north and south.

#### *F. Mt. Mueller*

A major fault runs across the eastern face of Mt. Mueller. This is apparent on the rise between the two branches of the Fourteen Mile Creek on the Port Davey Track and on the Kallista tram track about 250 feet below the top of the Tyenna-Styx divide. It apparently runs in a generally straight line. The bearing was difficult to obtain but was approximately south-east north-east. The fault cuts the Port Davey Track on the north-easterly curves on both sides of the larger (western, or second from Maynes') branch of Fourteen Mile Creek and

runs north of the Tyenna-Styx divide (Maydena Range saddle) on the Kallista tram south of Pine Hill. To the north it cuts through the rocky valley which separates the brown dolerite-capped spurs of Mt. Mueller from the white quartzite ridge of the Needles. To the north-east of this fault the rock is white quartzite and conglomerate, to the south-west it is permian glacial tillite, mudstones and Ross sandstones.

The map of Tasmania is so fragmentary that it cannot be used to trace this fault. I have not followed it beyond the Needles to the north and the Styx Valley to the south. It would be wrong to extend the fault line beyond the area in which it has been observed. However, in the district described in this paper, the Mueller fault is a dominating feature. It limits the western extension of the lower palaeozoic rocks and brings in again, to the west, the characteristic rocks which cover the surface eastward of Juneë. The Mueller block, however, stands at least 1500 feet higher than the rocks immediately east of Juneë and I regard it as an uplifted area rather than the Juneë lower-palaeozoic series as a faulted block dividing two portions of a single sequence of permian-triassic rocks. The Mueller block, is not merely a remnant of an unconformable succession succeeding the Juneë series lower in the valley and there is no doubt that a fault separates the two. This break cuts in a straight line across all physiographical features, and, throughout, permian-triassic strata lie against ordovician quartzites or mudstones of the Juneë series.

I have already described the section of the Mueller block exposed by the Port Davey track (Lewis, 1924) and have nothing further to add except that the tillite appears to be high in the permian and to correspond to the Woodbridge series. Farther south, on the summit of the Tyenna-Styx divide about a mile south-east of where the Kallista tram crosses are some beds of fossiliferous permian limestone. These are very thin and correspond to similar beds throughout southern Tasmania. Between them and the tillite are some hundreds of feet of dark grey, slaty mudstone the exact thickness of which could not be observed on account of the absence of exposures where dips could be measured. The dip appears to be south-west at about 10°. Nowhere could a floor of the permian series be discovered and I regard the Mueller block to be bounded by faults. Twelvetees records a report of the existence of granite in the Styx valley. This has never been confirmed by observation by a geologist. The locality where it has been mapped falls within the area of permian tillite and there is therefore every probability that observation was of erratics in those beds. I have already recorded tillite unusually full of granite in the Weld Valley not very far distant (Lewis, 1924 p. 22).

To the west and south of Mt. Mueller, ordovician limestones outcrop apparently from beneath the permian strata and overlie white quartzites of the Pine Hills series (Reid, 1921 Pl. X and Lewis, 1924 p. 19). Unfortunately, no such relationship can be confirmed in any locality I have been able to inspect, and I think that the probabilities point to more or less vertical block faulting in small wedge-shaped blocks of intricate pattern. This is to some extent confirmed by the reappearance of permian tillite in the Weld Valley below the 600-foot contour. The details of these faults have yet to be worked out. It appears to be agreed that the limestone overlies the quartzite and conglomerates in the Styx River and Mt. Bowes area as well as elsewhere.

#### *G. The Northern Tributaries of the Tyenna River*

White quartzite again outcrops a mile west of the commencement of the Adams-field pack track at Storey's. This rises to Sunshine Spur at 1450 feet two miles further on. Sunshine Spur is another crushed zone of anticlinal form, striking

south west. The quartzite runs in that direction across the valley to meet another anticlinal ridge which runs south east from the southern extremity of the Needles. Sunshine Spur shows at least two lines of intense crushing. These also run south west north east parallel to the anticlinal axis. They are heavily mineralised but only quartz veins and impregnations could be found. They have been well prospected and in one place a tunnel has been driven for a hundred feet or more to cut one of these crush zones, apparently without result.

To the north west of Sunshine Spur the quartzite is dipping at a high angle. It is succeeded by yellow mudstone containing fragments of trilobites which is clearly identical with that described earlier as occurring in the railway cuttings west of Junee. The mudstone appears to be about 200 feet in thickness and is succeeded by blue limestone of the Junee series, apparently conformably. In any case, dips and strikes of the quartzite, mudstone and limestone of the series correspond. The mudstone outcrops at the junction of the main Adamsfield pack track and the 'short cut' track which runs over the top of Sunshine Spur. (Forestry Department survey peg F.D. 8 stands at this junction). Some two hundred feet higher up the Spur the blue limestone outcrops. A fault with a throw of some 400-500 feet separates this limestone from the outcrop at Junee Cave, the fault being marked by the dolerite talus mentioned earlier.

The blue limestone is interrupted by another break which appears to cross the Adamsfield track about  $1\frac{1}{2}$  miles east of Chrisp's Hut. This break is marked by a mass of dolerite boulders. These cannot be a river terrace. They may be the result of a considerable landslip on the fault line or may, as mentioned above, be the eroded remnant of a dolerite still lying between the limestone and the overlying permian rocks. At Chrisp's Huts there are quantities of pebbles of grey slaty shale containing permian fossils. Twelvetreves mentions these and records permian strata at no great distance up the hill side north of the huts (which are still in the situation described by him) About  $\frac{1}{2}$  mile further west the blue Junee limestone is again outcropping across the track and can be traced for several hundred feet down the hill below the huts. Apparently a fault separates this occurrence from the limestone east of the dolerite boulders.

It is now suggested that some dolerite underlies the permian fossiliferous mudstone and the last mentioned rock succeeds the Junee limestone. Further, the real fault break occurs some  $\frac{1}{2}$  mile west of Chrisp's Huts from which point the Junee limestone outcrops to the top of the Tim Shea-Wherretts Lookout saddle where it is again capped by the dolerite of Wherrett's Lookout. The base of the latter dolerite would then correspond with the dolerite and permian mudstone of Chrisp's Huts. If this assumption is correct, the fault would have a throw of some 600 feet and would run east of Wherrett's Lookout. The higher block to the west would form Wherrett's Lookout, that feature having been produced by erosion of the uplifted block and the saddle between that eminence and the main Mt. Field escarpment would mark the lower block to the east of the fault. These faults all appear to be considerably older than the main Mt. Field uplift which cuts across stratigraphic boundaries and has produced an outstanding topographical feature.

Quartzite underlying these limestone beds forms the floor of the valley. The various suggested fault lines could not be traced under the dense forest and soil mantle. It appears that there are either fault breaks or anticlinal ridges crossing the valley in a more or less east-west direction but definite indications were not forthcoming.

In a few places (e.g. Wherrett's Look-out-Tim Shea saddle, the crest of Sunshine Spur and the north east side of Pine Hill) are outcrops of a white sandstone. This is associated with the quartzite-conglomerate but is considerably softer and is more easily weathered. It is probably the same rock as was observed by Hills (1921) on the Tiger Range and by Nye (1929) at Myrtle Creek and confused by them with the Queen River sandstone series. I place it tentatively between the quartzites and the mudstones of the Junee series. Impressions of *orthis* and of some other indeterminate fossils are occasionally to be found in it.

## *H. Tim Shea*

This block includes the mountain called Tim Shea (Mt. Stephens) from the saddle west of Wherretts Look-Out, westward to the northern end of the Needles and northward to the Florentine River. The geological structure is quite simple. Quartzite and conglomerate beds are tilting in a general northerly direction at a general inclination of 35°. This gives a vertical escarpment of nearly 2000 feet on the southern side and a simple dip slope on the northern. Mt. Tim Shea is the weathered residual of this escarpment. Some degree of compressional folding is also apparent. On the north-eastern slope of Tim Shea the dip is to a true bearing of 30° and at the western slope this has become a true bearing of about 300°. The change is over a distance of 5 miles and is regular, giving the block a shield shape without apparent break. It may thus be described as a pitching anticline although the fold is very slight in comparison with the dip and the area covered.

The rock of the ridge of Tim Shea is quartzite, quartzite-conglomerate and quartzite breccia. The conglomerate and breccia layers are relatively thin in comparison with the plain sand quartzite. This rock resembles the West Coast Range conglomerate series but may be distinguished from typical exposures of the latter rock in that the pebble contents of the conglomerate are usually smaller, less regularly distributed and the matrix, although sometimes of a rich pink colour is more usually light pink to white or grey. Layers of grits are common and there are layers which contain quite angular fragments and can only be called breccias.

The writer was anxious to investigate the site of Mr. Thomas Stephens' discovery of trilobite remains in 1902. Unfortunately Stephens did not leave any note on this point. R. Etheridge (1904) in describing the fossils gave no more precise locality than 'the Florentine River'. Twelvetreves (1908) who could have discussed the matter with Stephens wrote 'Near the saddle [i.e. between Wherretts Look-out and Tim Shea] are loose stones of yellow oxidised sandstone and clay containing impressions of *orthis* and trilobites. Although loose they are in such profusion as to suggest the proximity of the bed rock. They are evidently identical with the fossiliferous cambrian sandstone discovery by Mr. Thomas Stephens in 1902 on the flanks of Mt. Stephens, locally known as Tim Shea'. The fossils collected by Stephens and described by Etheridge have not again received comment in published accounts and have acquired an almost legendary importance far beyond their true value. Their locality also has become almost mythical. In 1937 the present writer made a special trip along the Adamsfield track to endeavour to obtain more light on the point. It cannot be stated at this stage that the present Adamsfield track follows exactly the track which was open in 1902 and 1908 but it cannot deviate much through the saddle. On that occasion not a trace either of trilobites or of the yellow sandstone boulders could be found at or near the saddle. That was before the identification of trilobite remains in the Junee railway cuttings.

The discovery of trilobites at Junee made it desirable to establish a stratigraphical correlation between these beds and the ones in which Stephens found

trilobites at Tim Shea. An exhaustive search established that a band of Junece mudstone containing a similar fossil suite including many fragments of trilobites overlies the quartzite which constitutes Tim Shea. These quartzites are dipping at a high angle to the north. A major fault traverses the Wherretts Look Out-Tim Shea saddle. To the east of this fault (between Chrisp's Huts and the highest point of the saddle) is blue Junece limestone. To the west of the fault from the highest point of the saddle for a mile and a half along the Adamsfield track, the quartzites are exposed and may be traced from the top of the Tim Shea ridge to this point. But a thin band of the Junece mudstone overlies these quartzites where the soft mudstone is not removed by erosion. This rock is not cut by the Adamsfield track but lies along a contour from 100 to 300 feet above the track from a point about 2 miles west of the saddle almost to the Little Florentine river. This belt is entirely covered by dense horizontal scrub and the mudstones were only discovered in some prospect holes to be mentioned later. It conforms in dip to the quartzite which it overlies. Towards the Little Florentine it is in turn overlain by blue Junece Limestone which dips conformably. Thus the same ascending sequence of quartzite, mudstone and limestone is again established from this locality. It must have been from boulders of this mudstone that Stephens collected the 'Florentine Valley' trilobites. There can be no doubt that the rock in which these were discovered is the same as that exposed in the railway cuttings at Junece. 'Northern flank of Tim Shea' is as accurate a location as possible. The writer traced these beds for a distance of about 5 miles, in isolated outcrops, mostly on spurs separating the small gullies which drain this country. The vertical thickness of the beds is about 200 feet but as the dip is at a high angle probably the stratigraphical thickness of the uneroded mudstone beds is less than this figure.

The blue Junece limestone which outcrops along the Adamsfield track for 2 miles east of the Florentine overlies the quartzite with the trilobite mudstone lying between. This limestone extends for a considerable distance into the Florentine valley (Hills, 1921). Hills recognized that the blue limestone conformably overlay the conglomerates of Tim Shea.

The mountain escarpment of Tim Shea is the direct result of the faulting of this block. Its eastern boundary is clearly marked by the north south fault through the Wherretts Look-Out-Tim Shea saddle which brings limestone into juxtaposition with underlying quartzite, the latter now standing at its summit just over 1000 feet higher in vertical measurement than the limestone east of the fault. The escarpment, so prominent from the south is the actual edge of the faulted block and the slight modification of this by erosion points to a recent date for the compressional movements which have produced this geographical divide between the Russell Falls River Valley and the Florentine Valley.

#### *I. The Needles*

This is a block of spectacular peaks of white quartzite reaching an elevation of 3500 feet and running for three miles southward from the western end of the Tim Shea ridge to the north eastern spurs of Mt. Mueller which mass it joins without any material geographical break. The Needles ridge runs approximately north and south. It is separated from Tim Shea by a deep saddle at 2100 feet. A south western plateau extension meets Mt. Mueller. From the south eastern end of the Needles a lower ridge runs south eastward into the Tyenna Valley to meet the south western extension of the ridge known as Sunshine Spur.

The Needles block is the most difficult to interpret of any in the area. At its northern end is a lower extension of pink quartzite dipping 50° to the north west.

These are clearly a continuation of the Tim Shea quartzites. The fault forming the southern escarpment of Tim Shea passes through a saddle between the higher portion of the Needles and this northern extension. A marked stratigraphical break passes down the longer axis of the Needles, as it were, dividing the ridge in half longitudinally. The western half dips to the north west at about 75' (actual dip is difficult to measure). The eastern half appears to dip in several directions—from about 80° to the west in places, through vertical to about 75° to the east. The Needles block is bounded to the south by the Mueller fault and the quartzites here abut against triassic sandstones.

At the foot of the Needles is a small outcrop of slate. This can be seen in the bed of the branch of the Tyenna River which runs from the Needles-Tim Shea saddle past the side of the 'Humboldt Mine' and which is shown on the accompanying plan as Clark's Creek. The slate here is seen to be of dull grey colour weathering to purple with interbedded layers of a yellowish colour. This is the only occurrence of slate in the area. From every point of view it appears to be correlatable with the Dundas slate. Its dip is at 80° to the east. This corresponds with the dip of the neighbouring escarpment of the Needles and at first sight may appear to indicate that the slate overlies the Needles quartzite. However, it does not appear that such can be the case. Nowhere else in the district is such a relationship observable and the top of the quartzite is open for inspection in a number of localities whereas its base is exposed nowhere else.

The writer's tentative explanation is that the Needles block is an overturned fold broken along its longer axis (see Plate V). The result of this movement has been to raise the quartzite bed which now forms the eastern escarpment of the Needles through a vertical position to an angle of 10° or so past the vertical and in the process to expose a portion of the underlying slate. The western side of the Needles ridge has merely been tilted to a very high angle. The eastern flank has been partially overturned across or against the western member. The only other alternative explanation which would fit the actual structure of the block is to postulate that the quartzite of the eastern flank of the Needles is a different series altogether from that of the western flank and of Tim Shea—a quartzite series underlying the slates. There appears no justification for such an assumption. Overturned folding is not uncommon and can produce any degree of successional variations. The writer assigns an early date for this movement (probably late Silurian to Devonian) and contemporaneous with the folding at Pine Hill, Junee, Sunshine and the mineralogenetic phase. There is in the area no indication of earth movements or disruption of the strata in pre-Silurian times.

In addition to this orogenic feature, the Needles appear to have been uplifted as a block in relatively recent times, probably by the same movement as produced the escarpment south of Tim Shea. This elevation was probably subsequent to the movements which caused the Mueller fault and contemporaneous with the uplift of the Mt. Field and other plateaux, i.e. early Pleistocene.

### The Sedimentary Succession

#### *The Junee Series*

The investigations here recorded establish a definite and easily identified series, which may conveniently be referred to as the 'Junee Series'. The sequence in the type area is:—

7. Grey shales with marine fossils of permian age.
6. Glacial conglomerates.
5. Erosion interval.



4. Diastrophic break.
3. Junee Series (iii) Blue Junee limestone.
  - (ii) Yellow mudstone containing trilobites and other fossils of lower ordovician age.
  - (i) Quartzites with conglomerates and breccias interbedded.
2. Probable unconformity.
1. Grey slates probably referable to Dundas Series.

The fossils collected from the yellow mudstone at Junee, Sunshine Spur and Tim Shea have been submitted to Dr. T. Kobayashi of Tokyo and Dr. F. W. Whitehouse of Brisbane for identification. The specimens are fragmentary and poorly preserved. Detailed descriptions are published in this volume. Etheridge preferred to assign an upper cambrian age while Kobayashi and Whitehouse, with more material to work on, prefer a horizon very low in the ordovician. The point is not of great importance to Tasmanian stratigraphy. The present view is that the faunal suite does not exactly correspond with that described from anywhere else in the world. On stratigraphical correlations, the present writer assigns an approximately corresponding horizon to the Junee mudstones and the Caroline Creek sandstones although some faunal differences are apparent. It appears preferable for the present to adopt the term 'Junee series' rather than to call these rocks 'Cambro-Ordovician' vague terms which implies, as far as it means anything, a definite correlation not yet established. The underlying quartzite and the overlying limestones must be of approximately the same age as the fossiliferous mudstones. It may be established later that the slates are of cambrian age but there is no justification at present for this assumption.

#### *West Coast Conglomerates and Gordon Limestones*

It is clear from the data now forthcoming from this area that either the Tim Shea-Needles-Pine Hill-Sunshine Spur quartzites and conglomerates are not members of the West Coast Range Conglomerate Series or else that series is not the basal member of the Silurian system as developed in Tasmania. For the present, the writer prefers to refrain from attempting to correlate the quartzite developed in this area with the conglomerates capping the West Coast Range. However, the point must throw a disturbing doubt on previously held ideas of the stratigraphical position of the type West Coast Range Conglomerates and direct special attention to the succession elsewhere.

The type Gordon River limestones as described by Gould and developed at the mouth of the Gordon and Franklin Rivers contain fossils of definitely Silurian age. Similar fossils are found in limestones and sandstones at Queenstown, Strahan and Zeehan. None of that suite were found in the area here described and the close association of the Junee limestones with the fossiliferous mudstones, now shown to be of lower ordovician age, clearly shows that the blue limestones as developed at Junee, in the valley of the Florentine and the Vale of Rasselas are not members of the Gordon River limestone series. For the present, they are best termed the Junee limestones and may be assigned a lower ordovician age. The writer considers that they are to be correlated with the limestones at Railton and Melrose in the north of the State.

The Silurian rocks as developed on the West Coast and consisting of the Gordon River limestones, Queen River slates and sandstones and included tuffs and porphyries are entirely missing from the area here described. If they ever existed, they must have been removed by erosion before the deposition of the permian shales as the latter appear to rest directly on the Junee limestones. There is no reason to assume that these rocks were ever deposited in this area.

With the exception of the tiny serpentine (?) outcrop at Maynes' and dolerite sills of trias-jura age capping Mt. Field-Mt. Mueller no igneous rocks were observed in the district. This fact distinguishes the area from those of the western mining fields where silurian sedimentary and igneous rocks occur together.

#### Correlation with the Adamsfield District

Mr. P. B. Nye in 1929 published an exhaustive report on the adjacent Adamsfield District with an excellent survey map. For many years, the West Coast Range Conglomerates series has been regarded as lying conformably and relatively closely below the Gordon River limestone of silurian age. The present writer makes no comment on this as far as the type localities at the mouth of the Gordon, in the Queen River and at Zeehan go but advances the opinion based on the advantage of the palaeontological evidence referred to earlier, that the Junee and Florentine limestones cannot be correlated with the Gordon River limestones. This fact may throw doubt on some of Nye's conclusions. The present writer has had an opportunity only for a brief visit to Adamsfield and has no comment to add to Nye's exhaustive observations but some revisions may prove necessary in regard to his conclusions on the geological succession at Adamsfield.

Nye (1929, p. 10) records purple slates at Adam River Falls. It is probably that these are members of the same series as the slates east of the Needles. Nye then states that the slates 'are unconformably overlain by the West Coast Range conglomerate series of the Ragged Mountains and Clear Hill, which form the base of the Silurian system in Tasmania'. It has been shown earlier that at the Needles the slates are overlain by quartzites and conglomerates which must be placed low in the ordovician system. Although there is no certain evidence that the Needles and Tim Shea conglomerates and quartzites are of the same series as those at Clear Hill and Ragged Mountain they bear a very close resemblance. The same may be said of the Thumbs and Saw Back conglomerates. Nye then states that these conglomerates are overlain conformably by quartzites followed by limestones. This is the same relationship as at Junee and Tim Shea. The 'numerous casts of a gasteropod' is further evidence of the relationship with the Junee mudstone which contains the gastropod figured by R. M. Johnston as *Straparollus (Maclurea) tasmanicus* Johnston (Johnston, 1888 pl. V fig. 7) but identified by Kobayashi as a liospirid (?*Sinuspea* sp.).

The present writer therefore considers that the Junee series as defined above is also to be found at Adamsfield and the correlation with the Gordon River limestone cannot be sustained in view of new palaeontological evidence now to hand. This again throws some doubt on the correlation of the sandstones and shales at Adamsfield with the Queen River Slate and Sandstone series. Unfortunately the fossils mentioned by Nye (1929, p. 13) do not now appear to be available for inspection. The point is important as no other occurrence of silurian rocks as far east as this has been recorded. The present writer therefore postulates that the Junee series extends over the Adamsfield area. This is merely a variation in interpretation from Nye's view and does not detract from the value of his observations. The extent of the correction now suggested is that the record of Silurian

rocks from this part of Tasmania should be replaced by rocks of the Junee series (ordovician). The conglomerate-quartzite stage should not be correlated with the West Coast Range conglomerate series until confirmatory data is forthcoming. If a correlation is proved, it will show that the West Coast Range conglomerates are of lower ordovician age and not silurian. It seems to the writer that a major fault cuts off the Thumbs-Denison Range conglomerate from the limestone of the Florentine and Rasselas valleys—a feature recognised by Twelvetrees (1908) and Nye (1929). A correlation between the Florentine limestones and the Thumbs conglomerate is therefore dangerous except on confirmatory evidence from other localities.

#### GEOLOGICAL STRUCTURE AND TOPOGRAPHICAL DEVELOPMENT

The Junee series is highly contorted and has suffered from extremes of regional metamorphism. This phase of diastrophism clearly occurred prior to the initiation of the permian sedimentation. The area provides no more definite data than this but it is reasonable to assume that the diastrophic phase here was contemporaneous with that in western Tasmania (late silurian to early carboniferous). It was responsible for the extreme folding seen at Pine Hill, Sunshine, the Needles and elsewhere. It is also reasonable to presume a long period of erosion between the diastrophic phase and the permian sedimentation but this area provides no definite data as to this.

It is clear that the lower palaeozoic rocks have not by any means remained stable since the deposits of permian-triassic rocks were laid upon the rocks contorted by the earlier movements. The movements during tertiary times have obscured the results of the shattering effects of the earlier movements which accompanied the intrusion of the huge dolerite sills which are such a feature of Tasmanian Geology.

The final deciphering of the tremendously complicated geological structure of Tasmania will eventually depend on a true conception of what has happened in an area in which lower palaeozoic rocks are in juxtaposition with permian-triassic sedimentaries and their intrusive dolerite. The head of the Tyenna Valley is the nearest area to Hobart presenting such features. It is tragic that, apparently, no complete section of carboniferous-permian strata from the original floor to the Ross sandstone is available for measurement. At Wynyard, the glacial beds, themselves of doubtful horizon within the permian system, are separated from the fossiliferous beds of Preolenna by wide basalt flows which probably conceal numerous faults. At Reidle Bay, Maria Island, we see only the summits of permian mountains rising nearly to top of the sedimentary series deposited on their irregular ridges. Elsewhere only fragments of the permian sediments are exposed. Throughout southern Tasmania the base and even the greater part of the marine series of permian age is below sea level or is obscured by faulted blocks. Even in the Junee district, which is taken as a typical area showing the lower to upper palaeozoic strata, the base of the permian beds is obscured by faulted blocks of older rocks. Some obscure exposure may yet be found (the area immediately above Chrisp's Huts appears promising but the junction is obscured by detritus) and for the present we must recognise that we have no knowledge of the actual thickness of the permian system, its exact geological horizon in relation to beds of similar age occurring elsewhere or the rocks which form its lower horizons.

In the area dealt with in this paper we see from east to west:—

1. The Derwent block at an elevation of 100 feet rising in rounded dolerite hills to an average of 500 feet and consisting of triassic sedimentary rocks, intruded by dolerite with later basalt flows.

- 2.—(a) The Mt. Field block to the north of the Tyenna Valley with permian mudstones at 350 feet to about 900 feet, succeeded by triassic sandstones rising to about 2500 feet and capped by dolerite rising to 4100 feet.
- (b) Corresponding with (a) to the south of the valley, the Maydena Range block rising to about 3000 feet, the lesser altitude being chiefly due to a thinner dolerite cap.
3. The Junee block averaging 1000-1200 feet in elevation with hills rising to 1450 feet and consisting of lower palaeozoic rocks divisible into the Junee series quartzites, conglomerates, mudstones and limestones.
4. The Needles-Tim Shea block rising to about 3500 feet, an obviously uplifted block of the palaeozoic rocks showing a base lower than the Junee series.
5. The Mt. Mueller block, rising to 4000 feet and consisting of permian strata, which, from the exposure at 1400 feet, are obviously lower in stratigraphical horizon than those exposed under the Mt. Field block at 300 feet. These extend upwards to some triassic sandstones at about 2500-3000 feet and are surmounted by dolerite but the whole block does not correspond in any way with the Mt. Field block.
6. The Mt. Bowes block, with Styx-Weld exposure of Junee limestones, corresponding approximately with the Junee block but rising a good deal higher and, in its western half, quartzites and slates, probably equivalent to the Needles quartzites and slates of the Humboldt Mine.
7. The Mt. Anne block, composed of lower palaeozoic rocks corresponding approximately with the Needles-Tim Shea block but capped with intrusive dolerite and rising to 4700 feet.
8. The Mt. Wedge block which corresponds approximately to the Mt. Anne block but with a thinner dolerite cap.
9. The Jubilee Range block which corresponds approximately to the Needles-Tim Shea block.
10. The Snowy Mountains block which corresponds approximately to the Mt. Mueller block.
11. The Mt. Styx block which corresponds approximately with the Mt. Field block and links these areas up with the Mt. Wellington range.

These blocks are bounded by major faults and are themselves much broken by lesser faults. It is very clear that the faulting which produced this pattern was later than the dolerite intrusions although movements contemporaneous with that event are in no wise precluded. The permian triassic sediments have been inclined gently in a general westerly direction. This influence is not apparent in the older rocks because of the previously folded structure of the latter. The influence which has produced this major fracturing appears to have been pressure in an east-west direction with a tilting of enormous blocks of country towards the west leaving marked escarpments along the eastern face of the breaks. There is evidence of some crushing and perhaps overthrusting to a slight degree at the western edges of the blocks (e.g. at National Park and Junee) with further considerable differential movement in a vertical direction along east-west lines of fracture. It is also clear that the uplifting of the plateau blocks was by stages and was sufficiently gradual to leave the pre-existing drainage systems, in the

main, undisturbed. Today the details of the topography are very little affected by rock types and the drainage often cuts at right angles across the structural framework of the area.

Before the geological structure of Tasmania as a geographical entity can be worked out, it is necessary to arrive at a solution of the problem of the dolerite intrusions. A preliminary phase of the investigation of this problem is a determination as to the original western extension of the dolerite sills. Western Tasmania, today, is predominantly occupied by pre-cambrian and lower palaeozoic rocks, the permian-triassic sedimentary series with its masses of intrusive dolerite being only met in relatively small and mutually isolated areas. The problem is whether this result has been produced by an earlier uplift of the western portion of the state followed by a far longer period of erosion than has been experienced over the central and eastern portion assisted perhaps by a thinner dolerite cap or whether it is due to an original westward limit to the newer rocks at much the same locality as we now see the boundary of these rocks against the more ancient groups. The solution of this problem will only be worked out through an intensive study of the whole border line country from New River to Cradle Mountain. The Tyenna Valley is the most accessible portion of this line.

Certain outstanding factors bearing on this problem are now apparent:—

1. The relationship between the older lower palaeozoic rocks and the newer permian-triassic blocks with the intrusive dolerite is in most cases a line or zone of major tectonic faults. As already stated, it is difficult or impossible to find a lower palaeozoic floor for the lowest members of the permian sedimentary series.
2. Dolerite of trias-jura age does intrude lower palaeozoic rocks and in a few places form caps to isolated mountains on which little or no permian-triassic sedimentary rocks are now found, e.g., Mt. Anne and Mt. Wedge (Lewis, 1924) Mt. Sedgwick (with a little permian rock) Mt. Dundas, Eldon Bluff (Johnston, 1888) Cradle Mt. and Barn Bluff (Benson, 1917). Again, the newer rocks are to be found west of the West Coast Range at Pt. Hibbs (Hills, 1914) and Henty River (Johnston, 1888; David, 1924).
3. Over most of the central and eastern portion of Tasmania, although the dolerite is very common it is not found in masses which are relatively extensive compared with the sedimentary rocks which it has intruded, not nearly as extensive as early geological maps would lead us to believe. Further, even in the more extensive occurrences, its thickness is seen to vary very considerably.
4. Along the north coast, pre-cambrian (?) and lower palaeozoic rocks appear at sea level in a number of localities. In other places the same coastal plain is occupied by permian-triassic rocks with intrusive dolerite. Farther inland, the lower plateau and the main central plateau show instances of dolerite and earlier rocks standing at the same level.
5. In general, Tasmanian physiography in its broader outlines appears to be little affected by the change from pre-cambrian and lower palaeozoic rock to permian-triassic series with its intrusive dolerite.

From the factors thus stated, the writer postulates that tertiary block faulting was the dominant influence in moulding the main outlines of our physiography. It also appears that dolerite did extend over the western portion of the State in some

localities at least. From this, however, it cannot be argued that the permian-triassic sedimentary rocks were deposited evenly over the whole of the present Tasmania. In fact, the evidence is to the contrary. (See e.g. Benson, 1917, although there are probably many faults in the Cradle Mt. area which have not yet been identified). The true position is probably that during the permian triassic deposition period there already existed a western land mass comprised of older rock. This was broken by arms of the sea and the newer sedimentary rocks were deposited in places upon the older topography. The whole western segment was gradually sinking and the area covered by these depositions was increasing until, perhaps, the whole of what is now western Tasmania was covered by the more recent members of the group. It also appears that the dolerite extended into or over the western portion of the State much as it did over the central and eastern part although perhaps with larger gaps and thinner sills.

The real influence moulding the existing physiography has been differential erosion caused by differential uplifts at different periods since the dolerite intrusions, including a marked deformation of the land surface at or about the time of the intrusions. Erosion first attacked the blocks which were elevated first and in these blocks it attacked most effectively the areas which were not protected by dolerite caps (many of the pre-cambrian and lower palaeozoic rocks are relatively soft). If this view is correct, western Tasmania must have been uplifted above the central and eastern two-thirds of the state some time in early to middle tertiary times. The uplift need not necessarily have been very considerable but it is clear that a peneplain was produced as evidenced by the general correspondence of the level of the summits of the western mountains irrespective of the age of the rocks. As further evidence we have the easterly flowing rivers, particularly the tributaries of the Derwent and the Huon rising in relatively low country amongst the earlier rocks and cutting straight through the dolerite capped plateaux which now stand considerably higher than the source of many of these rivers. We also have the great accumulations of river conglomerates consisting largely of pebbles of pre-cambrian and lower palaeozoic rocks in river valleys in which those rocks hardly occur. It appears therefore that at some time subsequent to the dolerite intrusions, Tasmania was subjected to tectonic influences which raised the western and north-eastern portion of the State. There followed a long period of erosion during which a single peneplain was produced with a surface occupied indiscriminately by pre-cambrian and lower palaeozoic rocks to the west and north east and with triassic sandstones with their intrusive dolerites in the centre and east. This involves the proposition that the earliest uplift was sufficient to bring the pre-permian floor to the level of the top of the dolerite sills. The actual height of this movement depends on the thickness of the permian-triassic sediments and intrusive dolerite cover of the moving blocks. No indication of this is yet forthcoming and, as already stated, it might not be nearly as considerable in the western portion of the State as the thickness of the corresponding series further eastward. The existence, at the surface, of lower palaeozoic or pre-cambrian rocks today is an indication of the location of this early uplift and not of segments which were not covered by permian-triassic sedimentations or affected by the dolerite intrusions. The subsequent peneplanation removed all the post-permian rocks, and, at least in some blocks, great thicknesses of lower palaeozoic rocks as well. For this reason, it becomes of great importance to study the relationship of the rare silurian series to existing physiography.

The foregoing proposition is now fairly generally accepted as is also the view that there has been more than one series of earth movements (see generally Nye

and Blake, 1938 pp. 12-14). The whole segment of the earth's crust now represented by Tasmania, with probably a large area now submerged, having been reduced to a peneplain after the first block faulting movements and showing a surface covered by pre-cambrian, lower palaeozoic, permian and triassic rocks in faulted blocks, a later (late miocene to pleistocene) phase of differential uplifts in several stages was experienced. The whole of Tasmania was affected and blocks were uplifted irrespective of rock type. It is clear that the faults attributable to this series of movements cut indiscriminately across older and newer rocks and the previous fault system and probably were not affected by the surviving results of the earlier movements. For this reason, any attempt to segregate Tasmanian physiography into areas where pre-cambrian or lower palaeozoic rocks appear on the surface as opposed to those areas where newer rocks only are found, is likely to produce a fundamental misconception. Certainly, difference in hardness of rock types and the relative thickness of dolerite sills has produced a marked effect on the details of the subsequent topography, as also has the relationship of the main fault lines to beds of differing hardness, but the effects of these extend only to details.

It is now the place to consider how the blocks mentioned earlier in this section fit into and illustrate the general statement of physiographic origins just set out. Presuming a topography over the area described in this paper more or less gently sloping towards the eastward as the result of the erosion period prior to the latest uplift the peneplained physiography resulting from the first uplift would have been as follows:-

A more elevated portion of the country consisting of pre-cambrian or lower palaeozoic rocks over what is now the Frankland Ranges was succeeded towards the east by country where lower palaeozoic rocks occupied the surface with small elevated areas of dolerite now represented by Mts. Anne and Wedge, where the dolerite was originally intrusive into lower palaeozoic strata. Then came the Mt. Mueller block of permian-triassic sediments capped with the dolerite of an intrusion originally more than 2000 feet higher than the more westerly examples. This block must have escaped the earlier uplifts and have thus been protected from the degree of erosion which removed the higher levels of the dolerite sills and the triassic-permian rocks from the blocks to the west and south-west. Farther east the Juneë block brought the lower palaeozoic rocks again to the surface corresponding approximately to the Mt. Anne-Mt. Wedge blocks but here there was no lower sill of dolerite to afford further protection against erosion. The eastern section of this area was occupied by dolerite covered country now represented by the Mt. Field-Maydena Range and country to the southward. This area was protected from further erosion by its lower elevation, perhaps very little above sea level. This indicates that the western blocks together with the Juneë block felt the earlier uplift and consequent erosion to a depth of at least 2000 feet below the stratigraphical horizon affected in the Mt. Mueller block and the country to the eastward, which did not suffer any uplift at this stage. It also indicates the presence of a lower dolerite sill in places, e.g. Mt. Anne and Mt. Wedge, which was missing over much of the Juneë block and probably over the country west of Mt. Wedge. At this stage Mt. Mueller probably stood out as the main watershed and the present drainage system was initiated. The country sloped thence southward, northward and eastward over a surface mainly of rolling dolerite hills but occupied in places by lower palaeozoic rocks.

The Mueller, and Juneë faults with, probably, many unidentified breaks are the result of the earlier period of block-faulting movements. These have little

effect on present day physiography, a fact which distinguishes them from the more recent fracturing of the countryside, such as the Tim Shea and Mt. Field escarpment faults and points definitely to the existence of at least two phases of earth movements since the intrusive dolerite sills were exposed. It also forms the basis for the proposition that prior to the development of the present topography the surface of this part of Tasmania was occupied by irregular blocks consisting more or less indiscriminately of lower palaeozoic rocks and more recent rocks with their intrusive dolerite sills. Unless this were so, it is difficult to see any explanation for the variety of rock types displayed by neighbouring blocks at the present time nor can this be accounted for by one cycle of erosion since the last uplift in view of the great difference in depth to which different blocks must have been eroded at some time to expose rocks which may have had originally a stratigraphical difference perhaps approaching 10,000 feet.

If the foregoing hypothesis is correct, western Tasmania must have been subjected to block faulting movements at an earlier date than the central and eastern portion of the State. These must have been most intense along the arch of schistose rocks stretching from Cox Bight to Cradle Mt. and from which even the lower palaeozoic rocks have been eroded, assuming that they ever covered this chain of most ancient highlands. Towards the eastern edge of this first uplift the elevation was not felt everywhere and certain blocks were not uplifted at all, even their higher strata thus virtually escaping erosion. The area Weld-Tyenna-Florentine valleys was portion of such a border area of differential uplift and the north and north-western coasts and Fingal districts were other similar areas.

The present topography was initiated by the series of block faulting movements which occurred about the time of the lake deposits containing cinnamon flora generally assigned to the middle-late miocene. It appears that the existing plateaux were uplifted by one influence which exerted similar force over the island, but not sufficiently powerful to uplift the whole country as one block. Each of the plateaux was uplifted separately although more or less contemporaneously and to relatively the same height. The writer inclines to the view that the motion was slightly rotational, that is, tilting of a very considerable area towards the west leaving a sharp escarpment of the east, with, in many cases, an additional escarpment resembling a pressure ridge along the western limits. Each of these blocks is broken by many faults running approximately north and south and is separated from neighbouring blocks by major breaks running approximately east and west. The eastern, northern and southern boundaries of these blocks are marked by lines of parallel or slightly radiating faults bounding blocks which have either lagged in the general uplift from the edge of the moving block or have subsequently subsided. These do not usually present the features of a typical step fault zone as some exhibit features induced by extreme pressure and a study of their stratigraphy indicates that they are really portion of a belt shattered and differentially elevated by the uplifting pressure with occasional regressional movements in phases of adjustment.

It seems that this latest uplift commenced with an elevation of the whole countryside to a height averaging 1400 feet, or acted upon a countryside standing at this average altitude. The moving blocks were elevated to an average height of about 2500 feet with certain segments forced up to 3500-4000 feet and an occasional ridge where higher blocks were pressed against the older highlands to the west rising to 4500 feet. Subsequently there was a slightly but more generally



uplift of 400-500 feet over the whole island. The higher uplifts almost invariably occur along one edge of the 2500-foot uplift.

In the area described in this paper the most prominent uplifted plateau is the Mt. Field-Humboldt Range. This is bounded by obvious fault scarps some 3000 feet high along its western, southern, and eastern faces, although the southern and eastern scarps are somewhat obscured up to about the 2500 feet contour by lower blocks. Mt. Styx forms the edge of a similar plateau to the south and the Maydena Range is a narrow block, probably the residue of the 2500 feet uplift between the two higher plateaux. Mt. Mueller, Snowy Mountains and Mt. Anne are the eroded residuals of similar but smaller uplifts appearing as small segments 4000-4700 feet high rising about larger blocks of country which stands at an average of about 3000 feet.

The Tyenna River and the Styx River flow across the fault scarps of this last phase of uplifts. Very likely the maximum uplift did not affect their original valleys which have eroded through the scarps of the 1400 feet (e.g. at Westerway) and the 2500 feet uplift (e.g. isolating the Maydena Range). The uplift must have been sufficiently gradual to permit these rivers to erode their beds during its progress, as otherwise they would have been diverted northward or southward. They were probably assisted by east and west fault lines or zones. The Florentine Valley is probably flowing across a topography little affected by earth movements since the first phase of uplifting. Its valley is bounded to the eastward by the fault scarps forming the western boundaries of Mt. Mueller and Mt. Humboldt. These faults may have diverted the drainage to the northward from the wide tract of country moulded by the first uplift. Similarly, the Huon flows southward past the Mt. Anne uplift until it turns east and cuts through all the plateaux in its path. The Weld passed down the unaffected country between the Anne and the Snowy Mountains uplift. The Gordon flows in country affected by the first uplift only and its behaviour at the Great Bend is further evidence of this earlier uplift of the western mountains.

Tim Shea is bounded to the south by a fault scarp of obviously recent date. The other faults which cut the Junee River series, although not such prominent physiography features are probably of the same date and appear to be much more recent than the Mueller and Junee Faults. The fault escarpments bounding the western face of the Humboldt plateau and the eastern faces of the Thumbs and Denison Range are the most outstanding elements of the physiography of the area. They appear to have no relationship to the faults which have brought blocks of rock of different stratigraphical horizons to the same level and must be regarded as the results of more recent movements. It appears as if these or relatively contemporaneous movements have also affected the intervening lower palaeozoic rocks, for example, tilting the Tim Shea block to produce its southern escarpment. Similar influences have probably been responsible for the framework of all western mountains. This factor seriously complicates the deciphering of our physiography and before definite results can be achieved the various phases of block faulting must be disentangled.

Saddles and larger physiographic gaps between mountains ranges may be capable of explanation as old river valleys cut off by block faulting uplift and modified by a consequent adjustment of drainage. This explanation is suggested for the saddles to the east and west of Tim Shea, features which are difficult to explain as the result of erosion during the present drainage cycle. The marked difference between the extremely juvenile drainage of the Tyenna valley and the mature

topography of the Florentine Valley can be accounted for by the interruption of portion of an older system by differential earth movements.

As to dates of the earth movements which have produced the dominant physiographic features, the only guide yet forthcoming is that provided by pleistocene glaciation. It appears to the present writer to be certain that the most recent earth movements were earlier than the Yolande glaciation. The presence of lower level (Malanna) glaciation in the Florentine Valley and the apparently uninterrupted glacial topography stretching northwards from Mts. Wedge, Anne and Mueller down the Florentine Valley to the latitude of Wyld's Cragg is an indication that this valley and its bounding ridges have not been materially affected by earth movements since before Malannan (early pleistocene) times. On the other hand, the absence of traces of this glaciation in the equally favourable terrain of the Tyenna Valley is probably due to their removal by subsequent river erosion aided, perhaps, by a slight general uplift of a few hundred feet and a consequent rejuvenation of the lower Derwent.

#### ECONOMIC GEOLOGY

Although no present mining leases are held in this area, it is not to be dismissed as of no economic importance. Twelvetees (1908) has described the old Humboldt Mine under the Needles. He records that it was first granted as a gold reward lease. Then a gossan outcrop and a copper lode with a parallel lode of ferro-manganese gossan yielding iron and silver were discovered. Galena and chalcopyrite also occurred. Twelvetees also records a large gossaneous outcrop of iron oxide between the mine and Junece. The slate between the site of the mine and the Tim Shea-Needles saddle carries in places large impregnations of pyrites. The mine was only worked between 1891 and 1894 and the various lodes were never opened out effectively. Subsequently, a small amount of work was done by a syndicate who were extracting a considerable amount of barytes in 1919. On the work done to date it would be wrong to condemn the occurrence as of no importance.

Twelvetees (1909) records scattered boulders of limonite on the south western slopes of Mt. Mueller (See also Lewis 1924) and persistent reports of copper ore in this locality frequently come to hand.

Pine Hill is a highly mineralised area with large impregnations of pyrites and haemitite. It has been trenched all over but no payable ore bodies have been discovered. Sunshine Spur is another mineralised zone. Gold has been found under Mt. Anne (Lewis, 1924). Gold and osmiridium have been washed from creeks throughout the area. Serpentine at Adamsfield is a source of osmiridium and probably of a little gold (Nye, 1929). This rock also occurs in the Styx and Florentine Valleys (Twelvetees, 1909) and may also occur at Maynes'. It is therefore established that the area carries ore formations. The practical work of investigation has been relatively slight and what has been done shows a grave misconception of the relationship between the geological structure of the country and the possible ore deposits.

With the exception of some possible occurrences of serpentine, no igneous rocks of the group usually associated in Tasmania with ore deposits have been found in this district. The sedimentary rocks, however, have been highly disturbed and the most intense diastrophic phase was probably contemporaneous with the movements which elsewhere produced various suites of igneous rocks and the associated ore bodies.

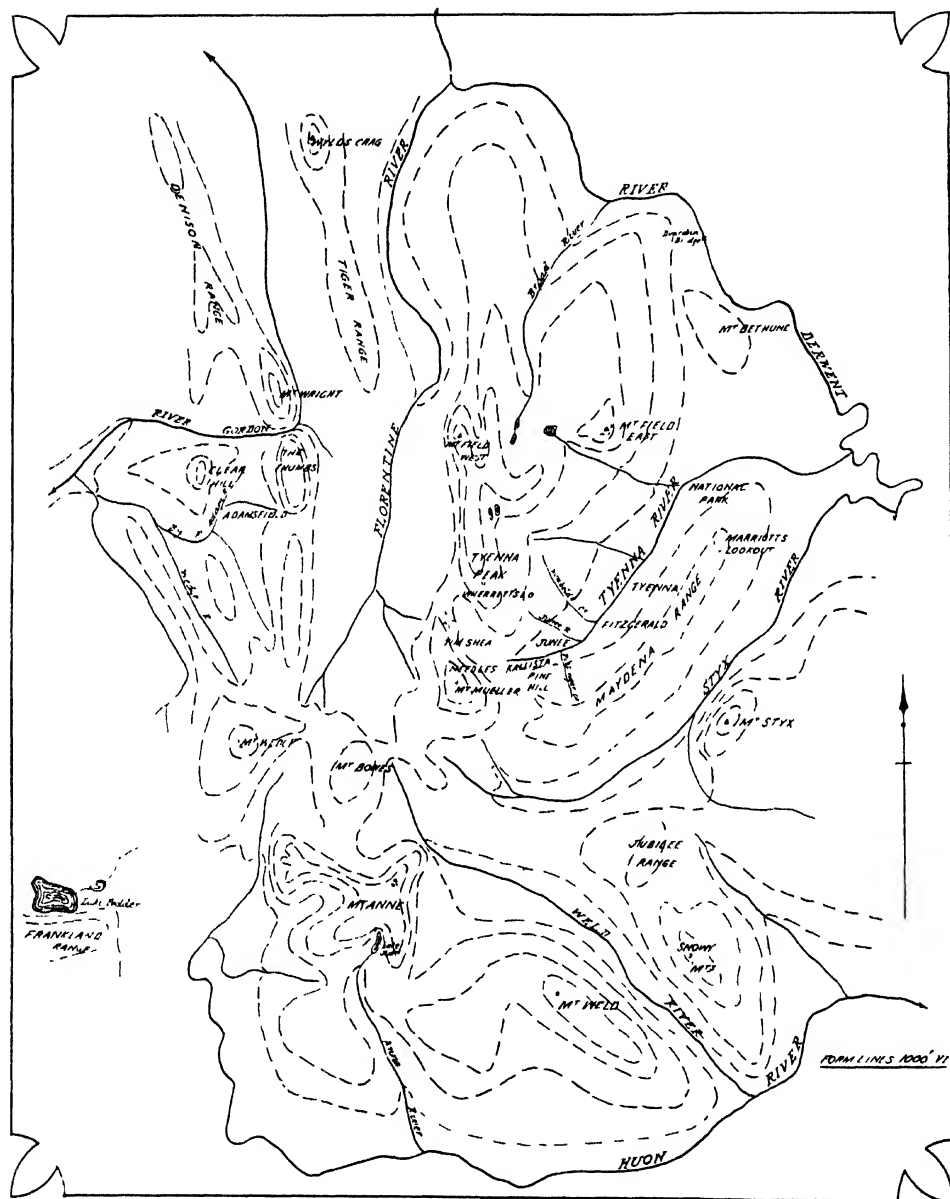
It is significant that most, if not all, of the major anticlines in the quartzite and conglomerate, the lowest member of the Junece series, are mineralised and also



- NYE, P. B., 1929.- The Osmiridium Deposits of the Adam-held District *Geol. Surv. Tas. Bull.* No. 39.
- NYE, P. B., AND BLAKE, F., 1938.--The Geology of and Mineral Deposits of Tasmania. *Geol. Surv. Tas. Bull.* No. 44.
- REID, A. M., 1921.—Osmiridium in Tasmania *Geol. Surv. Tas. Bull.* No. 32
- STEPHENS, T., 1910.—Geological Notes on the Country traversed by the Derwent Valley Railway extension. *Paps. Roy. Soc. Tas.* 1909 p. 170
- TWELVETREES, W. H., 1908 -Reports by Government Geologists. Report of Dept. Lands and Surveys. *Jour. and Paps. Parlt. Tas.* Vol. LIX Pap. 13 p. 25 1908
- ----- — , 1909 —Western Exploration. Report on Department of Mines. *Jour. and Paps. Parlt. Tas.* Vol. LXL Pap. 21 p. 25 1909
- VOISEY, A. H., 1939. The Upper Palaeozoic Rocks of Tasmania *Proc. Linn. Soc. of N.S.W.* Vol. LXIII 1938 p. 309.

**PLATE VII**

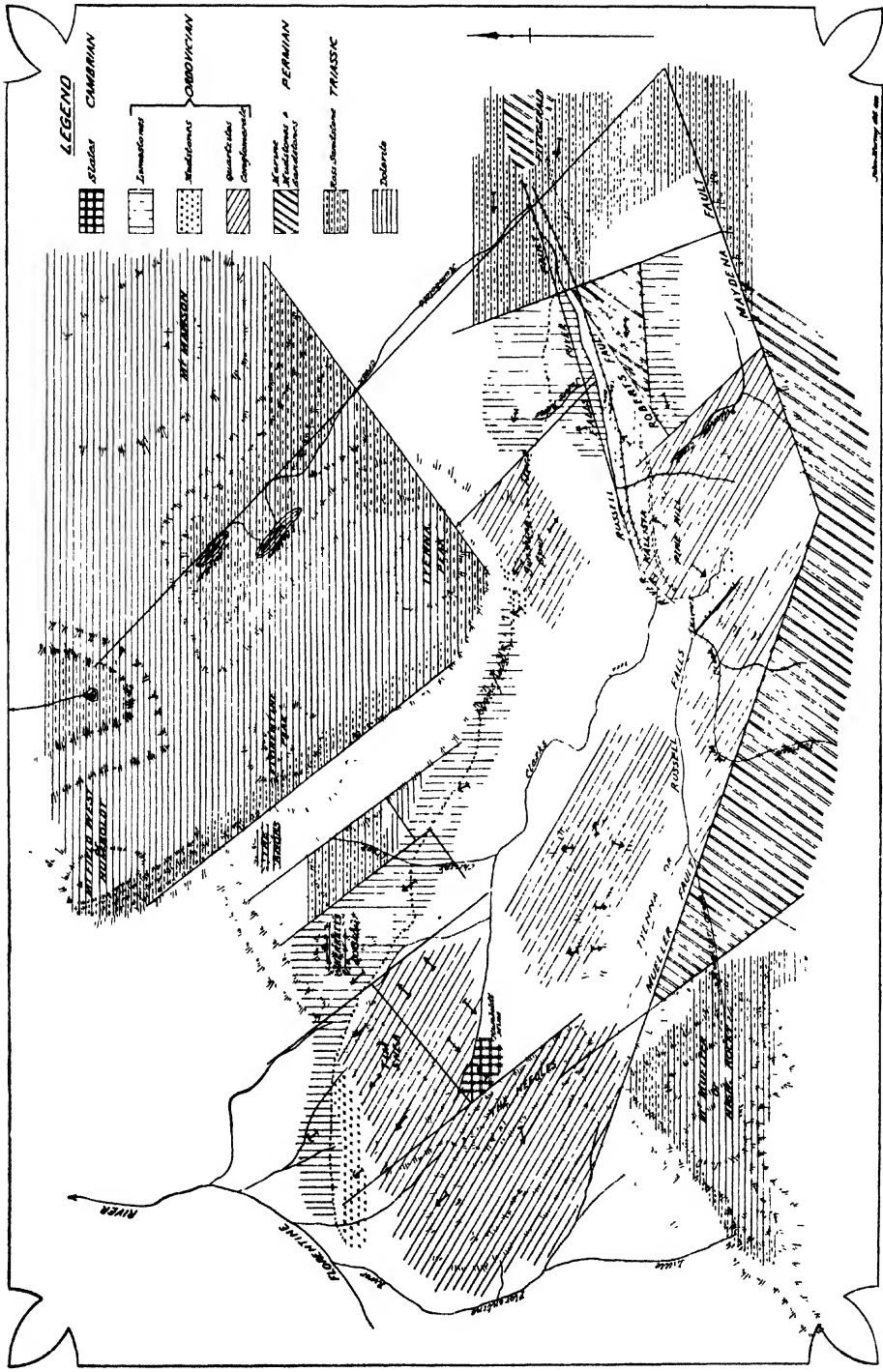
General locality plan. Scale: approx. 1 inch = 16 miles. Vertical interval 1000 feet



Scale: 1 inch = 16 miles [approx].

**PLATE VIII**

General geological sketch. Scale: approx. 1 inch — 4 miles.

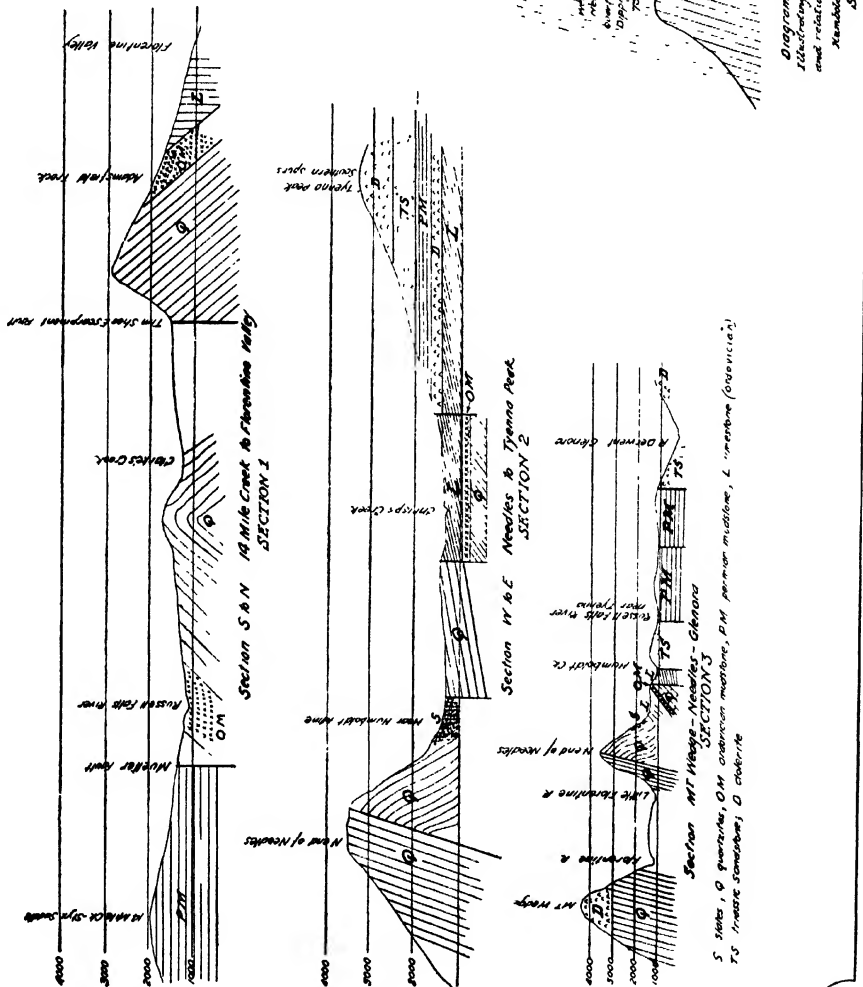


Scale: 1 inch = 4 miles (approx.)



**PLATE IX**

**P.M.** — Permian mudstone, tillite, limestone, etc.; **O.M.** — Ordovician mudstone of Junee series (trilobite bearing) **Q** — Ordovician quartzite and conglomerate of Junee series; **L.** — Ordovician limestone of Junee series, **S.** — Slate; **D.** — Dolerite, **T.S.** — Triassic sandstone.



Scale. 1 inch = 4 miles [approx]

#### PLATE X

FIG. I -- A general view looking north-west from Sunshine Spur. Distance to Mt. Mueller, Tim Shea, and Tyenna Peak, approx. 4 miles.

FIG. II -- Florentine Valley looking north from Tim Shea. Note general glacial aspect. Florentine River flows north in centre of photo. Gordon River flows south on right of Denison Range and then cuts westward between Denison Range and Thumbs. Note Humboldt-Tyenna Peak escarpment which shows permian strata at level of Florentine Valley while Wherrett's Look-Out and site of photo are in ordovician strata at higher level than triassic strata under Humboldt.

FIG. III -- Head of Tyenna Valley looking south-west from Tim Shea. Edge of Tim Shea escarpment shown on right and left of photo. Humboldt mine approx. where "Fig. III." is printed. Triassic strata appear on slopes of Mt. Mueller behind Needles and descend through permian beds to valley on left. Ordovician strata appear at summit of Needles and site of photo. Jubilee Range is of ordovician quartzite. Snowy Mts. are of dolerite capping triassic and permian strata. Note general physiographic accordance of blocks of different stratigraphic horizons.

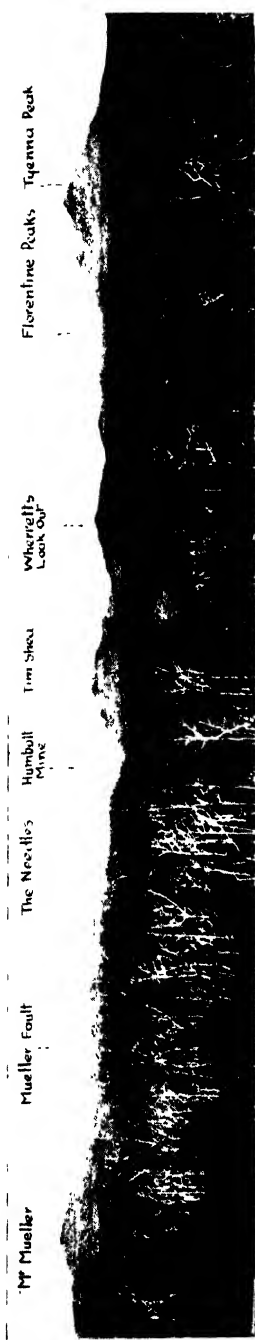


FIG. I

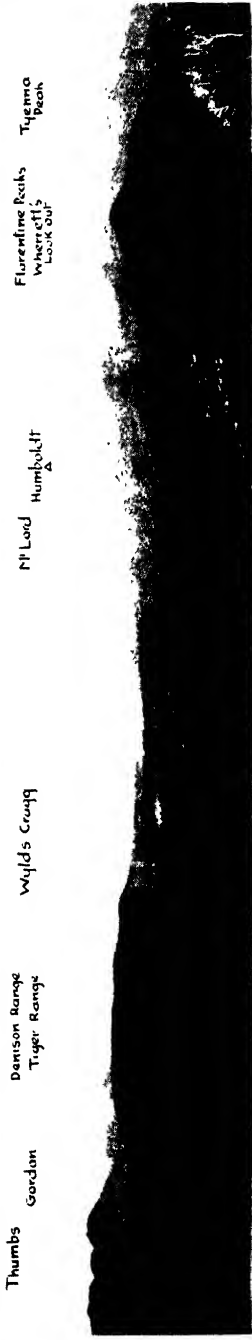


FIG. II



FIG. III



# Lower Ordovician Fossils from Junee, Tasmania

By

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(Communicated by A. N. Lewis, LL.D.)

(Read 13th November, 1939)

## PLATE XI

This fauna was discovered in a yellowish cream-coloured mudstone at Junee, Russell Falls River Valley, in the western of the two railway cuttings, two miles west of Junee railway station by Dr. A. N. Lewis. He submitted me his collection for palaeontological study and to him I owe many thanks. In the collection, one species of brachiopod, three species of gastropod and four species of trilobites are identified as follows:

*Orusia* (?) sp.

*Sinuopea* (?) sp.

*Roubidouria* (?) sp.

*Lecanospira tasmanensis* Kobayashi

*Asaphopsis junecensis* Kobayashi

*Asaphopsis* (?) *gracilicostatus* Kobayashi

*Tasmanaspis lewisi* Kobayashi

*Tasmanaspis longus* Kobayashi

A few brachiopods are contained in the collection but they are not very well preserved. Judging from the outline and numerous fine ribs which increase by intercalation, they may belong to one species. A mould of a ventral valve (Plate XI, fig. 1) shows a strong median septum and suggests the presence of pseudospondylium. A shallow median sinus appears to exist on the mould of the dorsal valve (Plate XI, fig. 2). Although these observations yield nothing definite for generic determination, they suggest a resemblance to *Orusia* or *Finkelburgia*. This species is remarkably similar to *Orusia lenticularis* (?) from the Florentine valley, i.e., Tim Shea, although the ribs appear a little coarser in the specimens described by Etheridge (1905).

Apart from *Lecanospira tasmanensis*, there are two specimens of gastropods one of which resembles *Roubidouxia* or some other liospirid and shows three volutions of a conical spire expanding rapidly and having a round apex. The other specimen exhibits the basal side of the broadly rounded last whorl with an open and deep umbilicus. As fine lines of growth faintly impressed in the latter show a bent backward, it belongs most probably to *Sinuopea* or its allies. The last five species in the list which are better preserved will be described in detail later.

*Asaphopsis juncensis* in addition to *Orusia* (?) sp. is certainly suggestive of close relationship of this fauna to the Tim Shea fauna. *Asaphopsis* is a characteristic trilobite which ranges from upper Tremadocian to Arenigian in the area extending from Southern France to Western Pacific regions through the Himalayan trough. *Lecanospira* is an American element of gastropod which is common in the Canadian, but ranges down to the Upper Ozarkian by Ulrich which, as discussed in my previous papers (Kobayashi, 1933, 1936), approximates to the Tremadocian according to the European standard. Therefore the two genera warrant the Lower Ordovician age of the fauna, the conclusion being supported also by the presence of imperfect brachiopods and gastropods. Incidentally, *Orusia* ranges from Upper Cambrian to Canadian while *Sinuopea* is common in Ulrich's Upper Ozarkian, although the lower limit of the genus is in the Potsdamian.

It is extraordinarily interesting to see that *Asaphopsis* and *Lecanospira*, distinct faunal elements of two different provinces, are found together at the same locality in Tasmania. *Tasmanaspis* is an endemic genus which may be a relic of a certain Cambrian family of trilobite.

The following is a description of the fossils:—

#### Family EUOMPHALIDAE de Koninck

##### Genus *Lecanospira* Ulrich, 1930

Many palaeontologists who followed Salter's generic concept of *Ophileta* had misunderstood the genus until Ulrich and Bridge (1930) pointed out that Salter's diagnosis does not fit in *Ophileta levata* on the basis of which Vanuxem's genus had originally been instituted. On that occasion, the joint authors referred six species to *Lecanospira* of Ulrich as follows:—

*Ophileta compacta* Salter, 1859, (Genotype) from the Beekmantown group of New York and Canada, Nittany dolomite and Longview limestone of the Appalachian Valley, Roubidoux formation of Missouri.

*Ophileta nerine* Billings, 1865, Quebec group, Div. F, St. John, Newfoundland.

*Ophileta altuensis* Sardeson, 1896, from the Oneota dolomite of Minnesota, Wisconsin and Iowa; Gasconade dolomite of Missouri.

*Lecanospira conferta* Ulrich in Adams, Butts, etc. (1926), same distribution as *compacta*.

*Lecanospira sigmoidea* Ulrich and Bridge, 1930, from the Roubidoux formation of Missouri

and later Dake and Bridge (1932) added:

*Lecanospira sancti-sabae* (Roemer) from the Ellenburger limestone (Roubidoux equivalent) in Texas

Still later Powell (1935) described two more species,

*Lecanospira tenuis* Powell, 1935 and

*Lecanospira profunda* Powell, 1935, both from the Oneota dolomite of Minnesota.

All of the nine species have so far been confined to the formations in North America which Ulrich referred to the Upper Ozarkian or Canadian. Therefore the discovery of *Lecanospira tasmanensis* in Tasmania, indeed bears, more than ordinary value for the study of palaeogeography.

*Lecanospira tasmanensis* Kobayashi, n.sp.

PLATE XI, FIG. 11

Shell of medium size planispiral, composed of four or five gradually expanding volutions; spire slightly sunken; diameter of a whorl less than twice that of the preceding; the ultimate whorl tends to detach from the penultimate one. The apertural margin on the umbilical side with the exception of one which shows a part of the apical side. In this specimen, the lateral wall of the last whorl is seen to be moderately convex. There is a low carina on the apical side from which the inner slope forms a concavo-convex curvature. None in the collection shows growth-line or any other facial marking. Most of the specimens are compressed laterally to some degree.

In the cross section of the whorl this resembles *L. altarensis*, but the umbilical side is nearly flat and the volution expands more rapidly in this species. It also stimulates *L. sigmoides* in the mode of coiling, but the number of coiling is no more than five in this whereas there are six to seven in *sigmoides*.

Family DIKELOCEPHALIDAE Miller

Subfamily DIKELOCEPHALININAE Kobayashi

Genus *Asaphopsis* Mansuy, 1920

- 1920 *Asaphopsis* Mansuy, Mem. du Serv. geol. de l'Indochine vol. 7, Fasc. 1, pp. 10-12.  
 1934. *Asaphopsis* Kobayashi, Jour. Coll. Sci. Imp. Univ. Tokyo, Sect. 2, vol. 3, pt. 8, pp. 489-491.  
 1936 *Asaphopsis* Kobayashi, Japan Jour. Geol. Geogr. vol. 13, p. 175.

The genus ranges from Upper Tremadocian to Arenigian and possibly extends into the lower Llandeilian and is distributed in the area extending from Southern Europe through the Himalayan trough to South Chosen on one side and to Tasmania on the other in the Western Pacific region. Eight species and one variety referred to this genus are as follows:

- (1) *Dickelocephalus* (?) *villebrun* Bergeron, 1895 from the Tremadoc superieur of Montagne Noire, Southern France.
- (2) *Dickelocephalus florentinus* R. Etheridge, jr. 1904, from the Lower Ordovician of the Florentine Valley, West Tasmania.
- (3) *Asaphopsis jacobii* Mansuy, 1920.
- (4) *Asaphopsis reedi* Mansuy, 1920 and
- (5) *Ogygites* (?) *annamensis* Mansuy, 1920 (except the free cheek in fig. 6a) from the Lower Ordovician Dongson sandstone of Thanh-hoa, North Annam.
- (6) (?) *Asaphus elegantulus* Gortani, 1934, (see Gortani, 1934), from the Lower Ordovician of Chisil Pass, Caracorum.
- (7) *Taihungshania welleri* Sheng, 1934, (see Sheng, 1934), and *Taihungshania welleri* var. *brevica* Sheng, 1934, from the Lower Ordovician Yinchufu series of NE Kiente-hsien, Chekiang, China.
- (8) *Asaphopsis nakamurai* Kobayashi, 1936, from the Tremadocian Tomkol shale of Doton-ri, Keisho-hokudo, South Chosen.

*Asaphopsis juncensis* from Juneo, Tasmania is an addition. *Asaphopsis* (?) *gracilicostatus* from the same locality is, though fragmentary, unquestionably a new species of the genus or an unnamed one closest to *Asaphopsis*.



*Asaphopsis juneensis* Kobayashi, n.sp.

## PLATE XI, FIGS. 6-9

A cranium in Plate XI, fig. 6 is strongly compressed laterally, reducing its original breadth but, nevertheless, the characteristics of dikelocephalid can hardly be overlooked.

The glabella tapers gently forward and is rounded in front. The axial furrow is rather deep. Three shallow lateral glabellar furrows seen on the left side of the cranium from the observer are oblique and more or less deepened at a short distance from the axial furrow with which they appear to join. The occipital furrow is transversal, shallow and narrow, and the neck-ring is almost uniform in breadth. On the left fixed cheek is observed a faint accurate groove which encloses a semicircular area adjacent to the glabellar base. The palpebral lobe located on the side of the glabellar center is relatively small, semicircular in outline, and slightly elevated; palpebral ridge almost indiscernible on the specimen. The preglabellar area is as long as two-thirds the glabella, broadly expanded and slightly concave.

In a pygidium in Plate XI, fig. 7 which is not deformed the anterior margin is somewhat arcuate. The axial lobe tapers gradually backward and is divided into more than eleven rings. The pleural lobe may be composed of about ten pleurae, the posterior ones of which are gradually bent backward. Except the articulating one which is regularly convex, the pleural ribs incline gently forward and rather steeply backward, forming terraces. Its marginal border is unpreserved.

Another pygidium in fig. 8 is similarly multisegmented. The same number of pleurae may be counted. The axial lobe is conical and appears somewhat pointed in the hind part. The doublure is considerably broad. A short spine which is a projection of the border issues from the middle point of the postero-lateral margin.

Still another specimen in fig. 9 which is an external cast is depressed longitudinally. The axial lobe is as wide as one-fifth the pygidium. The pleural segmentation becomes gradually obsolete from the axis to the margin until at length it disappears in a broad flat border.

In the last mentioned feature the third pygidium disagrees with the first one in which the furrows pass through the pleural lobe as far as the lobe is preserved on the specimen. Therefore should more material be procured, the difference may prove to be of specific value. Not one of the three pygidia is, however, complete and two of them are deformed rather badly.

Seeing that the doublure covers the outer half of the pygidium in the second specimen and that the furrows die out in the part of the pygidium in the third specimen, the difference of the furrows between the first and third pygidia may be introduced secondarily by the deformation through which the surface-relief was more reduced in the part where the dorsal shield was underlain by the flat doublure. While the third pygidium is depressed antero-laterally the second is compressed laterally. Nevertheless, they agree with each other in the conical axis, its proportion to the pleural lobe, broad flat brim and posterior spine, and the second has the same number of pleurae as the first pygidium. Therefore the reference of the three pygidia to identical species is for the time being, the best suggestion.

The semicircular area in the fixed cheek is the characteristic of *Dikelocephalina* and *Asaphopsis*. The former genus has generally a median postule on the neck ring which is absent in this species. A trace of the eye-ridge which is mostly

distinct in these genera can be seen on one side of the glabella, but on the other side, interrupted by an accidental oblique fold which was caused by the lateral compression, it is almost completely obsolete. The broadly rounded preglabellar field appears to suggest an alliance to *Dikelocephalina* more than to *Asaphopsis* but in the relatively posterior position of the pygidial spine which is one of the chief distinctions between the two genera shows it to be a member of *Asaphopsis*.

This cranidium can easily be distinguished from those of *nakamurai* and *villebruni* by its subcircular preglabellar area. The pygidium of this species is quite different from those of *villebruni*, *nakamurai* and *elegantulus* in outline. The axial lobe is broader and the posterior spine is shorter in this pygidium than in those of *welleri* and *welleri brevis*. The segmentation is more numerous in this than in the pygidia of *reedi* and *jacobi*. If the pygidium of *florentinensis* is correctly illustrated, the pleural groove is much stronger in that species. Besides these distinctions, the nearly straight lateral margin which is subparallel to the axis and the short spine which is produced posteriorly are the distinguishing characteristics of this species.

*Asaphopsis*(?) *gracilicostatus* Kobayashi, n.sp.

PLATE XI, FIG. 10

An incomplete pygidium at hand, insofar as can be judged from its nearly flat or slightly convex marginal border, short postero-lateral spine and pleural ribs which die out gradually within the border, belongs more probably to *Asaphopsis* than to any other genus. A groove along the inner margin of the border may be a crack along the inner outline of the doublure which was introduced by the secondary depression in the dorso-ventral direction.

The most distinct characteristic of this species lies in its fine relatively numerous elevated pleural ribs which are intervened by flat and broad depressions, the feature of which cannot be seen in all other species of *Asaphopsis* so far known. Therefore either this is an aberrant form of *Asaphopsis*, or it belongs to an unnamed genus close to *Asaphopsis*, the decision depending upon the find of other parts of the carapace.

Family ASAPHISCIDAE Raymond (?)

Genus *Tasmanaspis* Kobayashi, n. gen.

This comprises Lower Ordovician trilobites having subovate glabella without lateral furrows with the exception of the occipital one, relatively large eyes close to the posterior of the glabella and the frontal limb and rim forming convexo-concave curvature.

It resembles Upper Cambrian *Blountia* and its allies rather than any Ordovician genera. Its relatively large posterior eyes and faint frontal groove are distinguishing characteristics of the genus.

Type *Tasmanaspis lewisi* Kobayashi.

*Tasmanaspis lewisi* Kobayashi, n.sp.

PLATE XI, FIGS 3-4

Cranidium broad; glabella subovate, occupying two-thirds the length of cranidium and half the breadth of the cranidium measured through the eyes; circumglabellar and occipital furrows deep; no lateral glabellar furrows; occipital ring

narrows laterally from the median point; palpebral lobes large and opposed on both sides of the glabella in line with its center; palpebral ridge absent; postero-lateral limb of the fixed cheek transversally elongated and grooved along its middle; frontal limb convex in the inner and concave in the outer side and bordered by a narrow and slightly elevated frontal rim; anterior branch of the facial suture describes a semicircle in front of the eye; the suture posterior to the eye transversal and abruptly bent backward near the lateral extremity of the postero-lateral limb of the fixed cheek.

A free cheek found associated with the cranium is convex and bordered by a narrow groove and rim; genal spine short. The course of the facial suture and curvature of the cheek in adjacency to the suture fit fairly well with those of the cranium.

*Tasmanaspis longus* Kobayashi, n.sp.

#### PLATE XI, FIG. 5

At a glance this appears to be a deformed cranium of the preceding species by lateral compression, but close examination will soon reveal specific distinctions. This cranium differs from the preceding in its elongated cranium, almost straight anterior facial suture, distinct eye-band and uniform breadth of the neck-ring. The length of the preglabellar area corresponds to about half of the glabella in the preceding and to about one-third of it in the present species. Furthermore the palpebral lobe is relatively posterior in this species.

#### REFERENCES

- ADAMS, G. I., BUTTS, C., STEPHENSON, L. W., AND COOKE, W., 1926. Geology of Alabama, *Geol. Surv. Alabama*, Special Rep. no. 14.
- DAKE, C. L., AND BRIDGE, J., 1932 - Faunal Correlation of the Ellenburger Limestone of Texas, *Bull. Geol. Soc. Amer.* vol. 43.
- ETHERIDGE, R., JNR., 1905.—Trilobite Remains Collected in the Florentine Valley, West Tasmania, *Rec. Austr. Mus.* vol. 5, No. 2.
- GORTANI, M., 1934.—Fossili Ordoviciani del Caracorum, *Spedizione Italiana del Filippi nell' Himalaya, Caracorum e Turchestan Cinese* (1913-14), ser. 2, vol. 5.
- KOBAYASHI, T., 1933.—The Ozarkian Question and My View, *Jour. Geol. Soc. Tokyo*, vol. 40.
- — — — —, 1936. —The Natural Boundary between the Cambrian and Ordovician Systems Discussed from the Asiatic Standpoint, *Rep. of XVI Inter. Geol. Congr. Washington*, 1933.
- POWELL, L. H., 1935.—A Study of the Ozarkian Faunas of Southeastern Minnesota, *Sci. Mus. Saint Paul Inst. Sci. Bull.* No. 1.
- SHENG, S. F., 1934 —Lower Ordovician Trilobite Faunas of Chekiang, *Palaeontol. Sinica*, Ser. B, vol. 3., Fasc. 1.
- THORAL, M., 1935 —Contribution a l'Étude Paléontologique de l'Ordovicien de la Montagne Noire et Révision sommaire de la Fauna Cambrienne de la Montagne Noire.

#### PLATE XI

FIGS 1-2 —*Orusia* (?) sp. Ventral and Dorsal Valves. x2

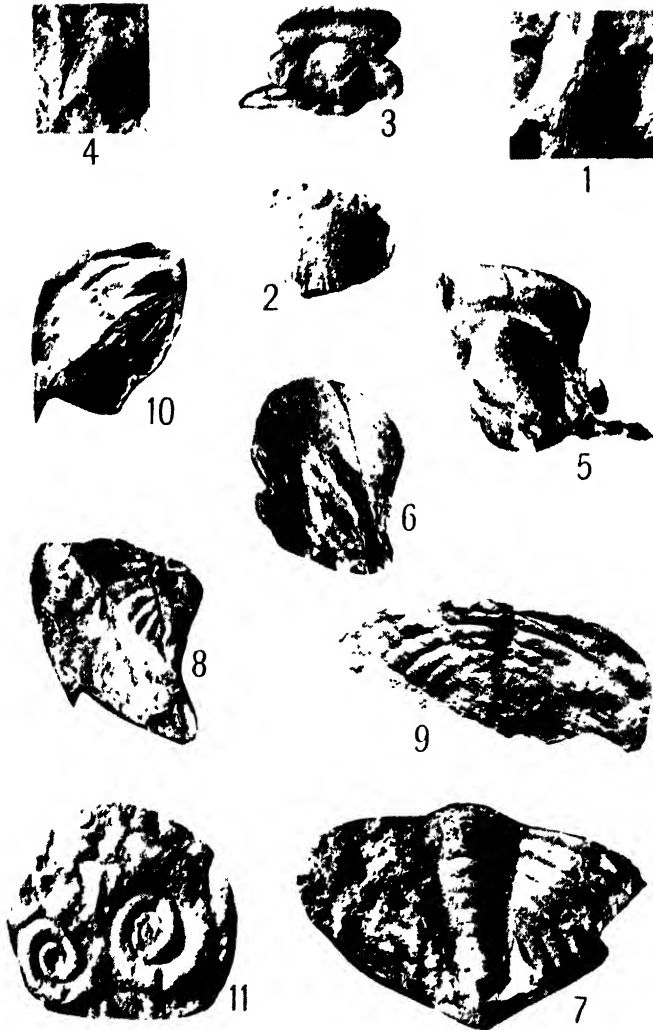
FIGS. 3-4.—*Tasmanaspis lewisii* Kobayashi. Holotype Cranium and Associated Free Cheek. x3

FIG. 5.—*Tasmanaspis longus* Kobayashi. Cranium. x3

FIGS. 6-9.—*Asaphopsis juneensis* Kobayashi. Holotype Cranium and three paratype Pygidia. Natural size

FIG. 10.—*Asaphopsis* (?) *gracilistatus* Kobayashi. Pygidium. Natural size

FIG. 11.—*Lecanospira tasmanensis* Kobayashi. Umbilical view. Natural size





# Lower Ordovician Fossils from Caroline Creek, near Latrobe, Mersey River District, Tasmania

By

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(Communicated by A. N. Lewis, LL.D.)

(Read 13th November, 1939)

## PLATE XII

Since Etheridge (1883) described this fauna, the generic references of the trilobites contained have been discussed by Johnston (1888) and again by Etheridge (1919). In 1936 I revised the fauna with fresh material kept in the British Museum of Natural History at London (Kobayashi, 1936). Recently, Dr. A. N. Lewis provided me with a new collection and this paper deals with the results obtained in studying it. Here I wish to tender my sincere thanks to Dr. Lewis for having given me the opportunity to make this interesting study.

The new collection contains most of the known species apart from a few new forms. The determinations by Etheridge and myself are tabulated below:

### *Etheridge's Determination.*

*Ophileta* (?) sp.

*Conocephalites* cfr. *stephensi* )

*Dikelocephalus tasmanicus* )

*Asaphus* sp. (a)

*Asaphus* sp. (b)

*Ptychoparia* (?) *carolinensis*

*Ptychoparia* (?) *johnstoni*

*Ptychoparia* (?) *tasmanicus*

### *My Determination*

Brachiopod, gen. et. sp. undt. (2 spp.)

Euomphalidae, gen. et. sp. undt.

*Cryptolites* sp. undt.

*Tasmanocephalus stephensi* (Etheridge)

*Asaphellus lewisi*, n. sp.

*Etheridgaspis carolinensis* (Etheridge)

*Etheridgaspis johnstoni* (Etheridge)

*Carolinites bulbosa*, n. sp.

*Carolinites quadrata*, n. sp.

*Carolinites* (?) *tasmanicus* (Etheridge)

*Prosopiscus subquadratus*, n. sp.

Free cheek gen. et. sp. undet.

The Caroline Creek fauna comprises fourteen species which are distributed in two genera of Brachiopoda, two genera of Gastropoda and five genera of Trilobita among which two indeterminable species of brachiopod, *Ophileta* (?) sp., *Cryptolites* sp. and a detached free cheek of trilobite of which little is known may be omitted in this discussion. *Asaphus* sp. (a) is not contained in the collection at hand, but if the pygidium with the smooth pleural lobe and concave border in

fig. 5 and the forked hypostoma in fig. 7 (Etheridge 1883) be combined in one species, the acquired form would belong to *Isoteloides* or some other genus in the Asaphinae.

*Asaphellus* is the characteristic Tremadocian genus. The species *lewisii* described in the present paper is near *Asaphellus* but its exact generic position is uncertain. Nevertheless, it is noteworthy that the species is closely allied to *Asaphellus* (?) *stenocephalus* (Mansuy). *Prosopiscus* (?) *subquadratus* resembles P. (?) *cheiruroides* which occurs at Thanh-hoi in association with a few species of *Asaphopsis* and *Asaphellus* (?) *stenocephalus*. The generic position of the cheirurids is, however, uncertain. *Tasmanocephalus* is allied to *Chosenia* in South Chosen and *Wutimgia* in South Manchuria, both Lower Ordovician members.

*Carolinites* and *Etheridgaspis* are such peculiar trilobites that it is difficult to settle even their family-references. At a glance, the former resembles *Onchonotus*, especially *O. orientalis* from the Tomkolian of South Chosen (Kobayashi, 1934) but the large oblique eye shows that it is a terminal branch of the Komaspidae rather than of the Solenopleuridae. In the pitted furrows of the glabella the latter looks like *Tostonia* and *Moxonia* but disagrees with them in most other features. It resembles also Irvingellids in the lateral view of the cranidium but the eye is not so developed as in the Irvingelloids. In my opinion, it may indicate an aberrant branch probably of the Solenopleuridae. Of the five trilobites, the former two trilobites in addition to the coiled gastropods indicate the Ordovician age of the fauna and the rest of the trilobites which are presumably relics of the Cambrian trilobite families suggest that the age is of the early part of the Ordovician period, the view being upheld by the inclusion of deeply forked hypostoma of the Asaphidae. The palaeontological evidences so far obtained are, however, insufficient to determine the age with any further accuracy. Through "*Asaphellus*" and "*Prosopiscus*", some affinity of this fauna to that of the Dongson sandstone at Thanh-hoa cannot be overlooked and the latter maintains intimate relations with the Caroline Creek fauna through *Asaphopsis*, but not a single species is found in common between the two faunas in Tasmania. The status appears to suggest a difference of fossil zones.

Finally a question remains as to which is the older between the Junee and Caroline Creek faunas, the solution of which naturally depends upon the field relation between the fossil horizons.

#### Family CRYPTOLITIDAE Ulrich and Schofield

##### Genus *Cryptolites* Conrad, 1838

##### *Cryptolites*, sp.

#### PLATE XII, FIG. 22

A gastropod is contained in the collection but only the last whorl is preserved. It coils in one plane or near to it and expands very rapidly. The umbilicus is as wide as one-third the diameter of the shell. The last whorl may not overlap the preceding one to a great extent. Its section is laterally compressed and its periphery is produced into a carinate band. Several low ribs run straight across the whorl. The aperture seems to be entire and simple.

This would appear to be a member of the Integradorsata of the Bellerophon-tacea (Reed, 1918) rather than of *Pelagiella*. It is most probably a *Cryptolites* and the straight ribs which are low and relatively wide are a specific characteristic.

## Family DAMESELLIDAE Kobayashi

Genus **Tasmanocephalus** Kobayashi, 1936**Tasmanocephalus stephensi** (Etheridge)

PLATE XII, FIG. 1-4

1883. *Conocephalites* (?) *stephensi* Etheridge, Pap. Roy. Soc. Tasm. 1882 (1883), p. 153, pl. 1, figs. 1-3.  
 1883. *Dikelocephalus tasmanicus* Etheridge, Pap. Roy. Soc. Tasm. *ibid.* p. 155, pl. 1, fig. 4.  
 1888. *Conocephalites stephensi* Johnston, Syst. Acc. Geol. Tasm. p. 37, pl. 1, figs. 3, 4, 14.  
 1888. *Dikelocephalus tasmanicus* Johnston, *ibid.* p. 37, Pl. I, fig. 8.  
 1919. *Crepicephalus tasmanicus* Etheridge, Trans. Roy. Soc. Austr., vol. 42, p. 390.  
 1936. *Tasmanocephalus stephensi* Kobayashi, Japan Jour. Geol. Geogr., vol. 13, p. 180.  
 1936. *Taihungshania tasmanensis* Kobayashi, Japan Jour. Geol. Geogr., vol. 13, p. 179.

In a previous paper, I proposed the new generic name, *Tasmanocephalus* for *Conocephalites* (?) *stephensi* and referred *Dikelocephalus tasmanicus* to *Taihungshania*. Then I could see neither a cephalon of *tasmanicus* nor a pygidium of *stephensi* in the collection in the British Museum. As I failed again to find either one of them in the other collection now at hand, I am inclined to accept Etheridge's view expressed in the following passage: 'Since my paper was written now many years ago, I have examined a quality of the Caroline Creek deposit. One result of this is inability to find any pygidia likely to associate themselves with the *Conocephalites* cephalon other than the *Dikelocephalus* tail or vice-versa. I can, therefore, only conclude they are one and the same.'

Excepting the presence of two posterior spines, the pygidium in question is different from those of *Dikelocephalus* and *Dikelocephalina* while, on the other hand, it resembles closely that of *Taihungshania* as I have suggested. Then how far the pygidia of *Tasmanocephalus* and *Taihungshania* differ from each other becomes a question. Close comparison shows that the pygidium of *tasmanicus* differs from any of the known species of *Taihungshania* in that the pleural groove is much wider than the pleural ridge, the interpleural groove is, although weak in the young stage (see fig. 4), well developed on the pleural ridge in the later stage of growth (see fig. 3), the extremity of the articulating margin is distinctly angulated, and the marginal border is frequently well defined by a groove. In *Tasmanocephalus*, the spines are widely divergent posteriorly whereas they are nearly parallel in *Taihungshania shui* Sun (see Sun, 1931), *T. shui brevis* Sun, *T. miqueli* Bergeron and *T. miqueli landayanensis* Thoral. As *T. miqueli flexuosa* Thoral (see Thoral, 1935) which is represented by the pygidium only is quite distinct from these forms of *Taihungshania* in its broad triangular outline and spines issuing from the antero-lateral points, further study is needed on the species, especially its cephalon, to determine whether or not it really belongs to *Taihungshania*.

At any rate, the pygidium of *tasmanicus* may be readily distinguished from that of *Taihungshania* and it probably belongs to *stephensi*. The genus in which the cephalon and pygidium are combined is indeed, more allied to *Chosenia* (Kobayashi, 1934) and *Wutingia* (Endo, 1935) than I formerly thought. All of the three Lower Ordovician genera agree with one another in the broad cranidium, long glabella provided with three pairs of lateral furrows, broad fixed cheek, large posterior eye and free cheek with genal spine on the cephalon and in the depressed marginal border and a pair of spines on the pygidium. The outline of the glabella which is subovate and bulbous in *Chosenia*, subquadrate, but slightly tapering forward in *Wutingia* and subquadrate but slightly expanding forward in *Tasmanocephalus* is the distinguishing characteristic.



## Family CHEIRURIDAE Salter

Genus **Prosopiscus** Salter, 1865**Prosopiscus(?) subquadratus**, n.sp.

## PLATE XII, FIG. 5

*Description*:—Glabella square, elevated above the cheek; dorsal furrow very deep; three pairs of lateral furrows short, deep and transversal, but disconnected in the axial part; occipital furrow bent forward in the middle; fixed cheek slightly narrower than the glabella and bent down laterally; palpebral lobe of medium size and opposed to the second lateral furrows; palpebral ridge faintly impressed; facial sutures anterior to the eyes nearly parallel and those posterior to them transverse and cutting the lateral margin at a point in front of the genal angle; frontal rim wire-like and depressed below the glabella; genal spine apparently absent; texture of the carapace unknown.

*Comparison*:—*Encrinurella insagensis* (Reed, 1906) and *E. martelli* (Reed, 1917) which are common in Southern Asia differ from this species in the outline of the glabella which expands forward in the Asiatic ones and further, in the furrows on the glabella which are disposed in a different manner. *Protopliomerops* has a longer glabella; oblique lateral furrows, more anterior eye and short genal spine. *Prosopiscus minus* (Mansuy, 1920) may be the nearest form but the glabella is longer in *minus*.

## Family KOMASPIDAE Kobayashi

Genus **Carolinites** new genus

*Diagnosis*:—Komaspidae without lateral glabellar furrows and with a narrow fixed cheek, large eyes and a raised frontal rim.

*Type*:—*Carolinites bulbosa* Kobayashi.

*Remark*:—This genus can readily be distinguished from irvingellids by its unfurrowed glabella.

**Carolinites bulbosa**, n.sp.

## PLATE XII, FIGS 6 AND 7

*Description*:—Glabella bulbous, expanded forward; no glabellar furrows except the occipital one which is deep; eye-band long and oblique; no frontal limb; frontal rim straight; marginal furrow deep.

*Observation*:—A pygidium which presumably belongs to this is semi-circular; axial lobe as wide as half the pygidium, distinctly elevated above the pleural lobe, and composed of three rings and a terminal subtriangular lobe; pleural part narrow, gently convex and faintly ribbed; marginal border of moderate breadth and flat. It is noted that this pygidium is, in the general aspect, allied to the one which I reported from British Columbia and referred to *Irvingellina* (Kobayashi, 1938).

**Carolinites quadrata**, n.sp.

## PLATE XII, FIGS. 8 AND 9

*Description*:—Glabella convex, subquadrate, slightly expanded forward, highly elevated above the fixed cheek; no furrows on the glabella except a strong occipital one; neck ring narrowing laterally; eye-band, long and oblique; fixed cheek

depressed and bent down to the front and back from the eye; frontal rim straight, wire-like, depressed in front of the glabella and separated from the glabella by a furrow.

***Carolinites* (?) *tasmanensis* (Etheridge)**

1887. *Bathyrus* (?) sp Etheridge, Proc Roy Soc. Tas 1882 (1883) p 157. Pl I, fig. 12

1888. *Bathyrus* (?) sp Johnston, Syst. Acc. Geol. Tas p 37. Pl. I, fig. 19.

1919. *Ptychoparia* (?) *tasmanensis* Etheridge, Trans. Roy. Soc. S. Australia vol. 43, p. 392.

This differs from *Carolinites bulbosa* in the presence of a narrow frontal limb, the anterior outline of the cranium which is gently convex forward, and broad free cheek. If the illustration is correctly drawn and the eye is small, this does not belong to *Carolinites*.

**Family SOLENOPLEURIDAE Angelin**

**Subfamily SOLENOPLEURINAE Kobayashi**

**Genus *Etheridgaspis* n.gen.**

*Diagnosis*:—Solenopleuridae with long subovate glabella, strong posterior glabellar pits and furrowed pleural ribs on the pygidium.

*Type*:—*Ptychoparia* (?) *carolinensis* Etheridge.

*Remarks*:—At a glance, Etheridge's *Carolinensis* in fig. 9 looks similar to the Irvingellid in its bulbous glabella, platform-like fixed cheek and the features in the front border, but upon closer study of the collection, I found that the resemblance is not so remarkable. In the Irvingellids, the eye is not closely set to the glabella and the fixed cheek is not so narrow. Furthermore, one or more lateral furrows generally run across the glabella in most genera of the Komaspidae except *Dartonaspis*.

As suggested in my previous paper, this genus is certainly more allied to the Solenopleuridae; and especially to *Menocephalites* Kobayashi, 1935, *Hystericurus* Raymond, 1913, and *Louchocephalus* Owen, 1852. The last mentioned genus is different from *Etheridgaspis* in its triangularly ovate glabella, occipital spine, broader fixed cheek and frontal limb, unfurrowed pleural rib of the pygidium and so forth. These distinctions except the spine applies to distinguish this genus from *Hystericurus* and moreover *Hystericurus* differs from this in its unfurrowed glabella. *Menocephalites* is different from this in the absent frontal limb and broader fixed cheek. Nevertheless it is allied to the three genera of the Solenopleuridae in many respects including the cranium and pygidium. The narrow fixed cheek, a pair of pits on the posterior part of the glabella and furrowed pleural ribs of the pygidium are the generic characteristics.

***Etheridgaspis carolinensis* (Etheridge)**

**PLATE XII, FIG. 10-11**

1883. *Conocephalites* sp. Etheridge, Proc. Roy. Soc. Tas 1882 (1883) p 156 and 162 pl. I, figs. 8-9 and (?) 11.

1888. *Loganellus* (?) or *Conocephalites* (?) sp Johnston, Syst. Acc. Geol. Tasm p 37, pl. I, figs. 7, 11, & (?) 16.

1919. *Ptychoparia* (?) *carolinensis* Etheridge, Trans. Roy. Soc. S. Australia, vol. 43, p. 361

*Description*:—Glabella large, regularly convex, very slightly expanding backward and rounded in front; circum-glabellar and occipital furrows strong; anterior lateral glabellar furrow indicated by a faint pit at about the middle point of the glabellar side and posterior one by an oblique depression which is pitted at a short

distance from the glabellar side; fixed cheek very narrow; but its posterior lateral limb is long and extends laterally; palpebral lobe relatively large and located slightly posterior to the middle of the cranidium; frontal limb narrower than the frontal rim and they are intervened by a groove; facial suture diagonal and cutting the frontal margin in front of the eye; surface granulated.

Free cheek bordered by a narrow furrow and rim; the marginal rim produced into a short genal spine; eye well developed and elevated above the gently convex free cheek.

*Comparison*:—I fear that Etheridge's illustrations may not be correctly drawn, because one specimen in figures 8 and 9 and the other in figure 11 which are different in the outline of the glabella and the number and direction of the lateral glabellar furrow were referred to one species. The specimen beforehand fits in neither one of the two exactly, but several characters are common between this and either one of Etheridge's. Mine has two pairs of lateral furrows in the glabella as the specimen in fig. 11. The glabellar outline simulates that in fig. 8, but is longer and slightly expanded in the posterior, although the expansion is not as wide as seen in fig. 11. It is intermediate between the two, but approaches closer to the one in fig. 8.

### *Etheridgaspis johnstoni* (Etheridge)

#### PLATE XII, FIGS. 12-14

1883. Second species Etheridge Proc. Roy. Soc. Tas. 1882 (1883) pp. 157, 162, Pl. 1, fig. 10  
 1888. *Loquellus* (?) or *Conocephalites* (?) sp. Johnston, Syst. Acc. Tas. p. 37, Pl. 1, fig. 10  
 1919. *Ptychoparia* (?) *johnstoni* Etheridge, Trans. Roy. Soc. S. Australia, vol. 43, p. 392

*Description*:—Glabella long, conical, gently tapering forward, rounded in front, and distinctly elevated above the fixed cheek; circum-glabellar furrow very deep; anterior lateral furrow shallow and very faint; posterior lateral furrow represented by an oblique deep pit at a short distance from the glabellar side; occipital furrow deep; occipital ring almost uniform in breadth. Fixed cheek very narrow; palpebral lobe relatively large and located at the midlength of the glabella; postero-lateral limb of the fixed cheek extending laterally; frontal limb rudimentary; frontal rim depressed; facial sutures slightly divergent in front of the eyes and widely divergent posterior to them.

Pygidium semicircular, somewhat truncated, even sinuated at the hind; its anterior outline broadly arcuate; axis conical, rounded behind, highly elevated above the pleural lobe which is slightly convex, gently inclined toward the margin and divided by broad furrows into three intrapleural ribs in addition to an articulating one; the rib and furrow almost equally broad; each of the three ribs divided into riblets by an interpleural furrow; the riblet as well as the interpleural furrow run into the marginal border but the intrapleural furrow terminated in the inside of the elevated flat-topped border.

*Comparison*:—This species differs from the preceding in its narrower and more convex glabella which tapers forward more rapidly. Yet the difference is no more than specific.

At first I thought that Etheridge's *johnstoni* is a different species, insofar as the glabellar outline is concerned. However, as shown in fig. 14, an ill-preserved specimen assumes a similar aspect. Because it is quite probable that his specimen which is incomplete and perhaps incorrectly drawn in his illustration belongs to the same species, I hesitate to establish a new species for mine.

## Family ASAPHIDAE Burmeister

## Subfamily OGYGIOCARINAE Raymond

Genus *Asaphellus* Callaway, 1877

- 1877 *Asaphellus* Callaway, Q. J. G. Soc. London, vol. 33, p. 663.  
 1910 *Asaphellus* Raymond, Ann. Carnegie Mus., vol. 8, No. 1, p. 37.  
 1910 *Asaphellus* Grabau and Shimer, North American Index Fossils vol. 2, p. 290.  
 1913 *Asaphellus* Raymond in Zittel-Eastman's Text-Book vol. 1, p. 719.  
 1930. *Asaphellus* Reed, Ann. Mag. Nat. Hist. p. 313.  
 1934. *Asaphellus* Kobayashi Jour. Fac. Sci. Imp. Univ., Tokyo, Ser. 2, vol. 3, pt. 9.

The association of the detached hypostoma to the dorsal shield of *Asaphellus homfrayi* has been a moot question. Salter's (1866) hypostomata from Garth are distorted. One in fig. 9 which is laterally compressed is parallel-sided; the sides are expanded in the other in fig. 8 which is longitudinally depressed. Both have the elliptical body in addition to the lunate ridge behind. According to Reed (1931) 'the hypostoma which he (Callaway) attributed to *A. homfrayi* more probably belongs to *P. crofti* while that which he referred to the latter should, on the other hand, be assigned to *A. homfrayi*'. Callaway's (1877) hypostoma in fig. 2a shows the maculae divided by a median elevation at the rear. Raymond (1910) noted that the hypostoma of *Asaphellus gyracanthus* is similar to that of *Hemigyaspis colliena*. Only the latter which has the outline tapering backward and rounded at the hind was illustrated. Its macula-bearing ridge appears to be very narrow. Incidentally, *colliena* was later selected for the type of *Bellefontia* by Ulrich (1924). Although those hypostomata of *Asaphellus* differs in minor respects, all agree in the oblong outline, small anterior wings and large central body from which the maculae are distinctly separated. The specimen at hand belongs to this kind of hypostoma.

The isoteliform facial suture precludes this species from *Hemigyaspis* and its unforked hypostoma from *Isotelus*, *Isoteloides* or *Asaphelloides* to one of which it might otherwise belong. At length *Asaphellus*, *Paramegalaspis* and *Megalaspidella* remain for its comparison. When Thoräl (1935) established the genus, he overlooked *Asaphellus monticola* Raymond which has been described from the Middle Tremadocian at the Priori near Pierrerue and L'Chinian, Herault, South France. No mention is, however, given of its hypostoma and with the dorsal shield only its generic separation from *Paramegalaspis* is hardly possible. Thoräl compared the hypostoma of the genus with those of *Asaphellus* figured by Callaway (1877) and Matthew (1903) between which Matthew's was later referred to *Asaphellus obtectus* (Raymond, 1924) and Callaway's to *Platypeltis crofti* as mentioned already. The hypostomata of Raymond's *obtectus* as well as Matthew's *A. homfrayi* var. resembles that of *crofti*, instead of *homfrayi* in the subcircular outline. Compared to the hypostoma of *Asaphellus* which is figured out above, that of *Paramegalaspis* is different at least in the size of the anterior wing which is broader in the latter.

When I revised the Cambro-Ordovician shelly fauna of South America (Kobayashi, 1937) I established a new genus, *Megalaspidella*, and *Asaphelloides*, a new subgenus of *Asaphellus*, in the latter of which the hypostoma is slightly forked but the hypostoma of the former was unknown. Recently Harrington (1938) amplified the Lower Ordovician fauna in Argentina in which many asaphids are contained. Among three hypostomata attributed to *Asaphellus juvanus*, one in figs. 4 and 16 are broad, rounded, and provided with large anterior wings showing the closest alliance to *Paramegalaspis* and then next to *Megalaspidella*.

Judging from their hypostomata, *Megalaspidella* and *Paramegalaspis* are similar but the two can be distinguished from *Asaphellus* s. str. as well as *Asaphelloides* on the dorsal view. *Megalaspidella* is different from the other three in its glabella which is conical, rounded in front, and fairly well defined by the dorsal furrow, and in its pygidium which is segmented as in *Megalaspis*. I do not intend to ignore the classificatory value of the hypostoma, but if the minor difference of it is too highly evaluated, it makes it impossible to determine many of the asaphids. In my opinion, it is most expedient to take *Paramegalaspis* for a subgenus of *Asaphellus*, instead of *Megalaspis*, because there is no distinction of the generic value on the dorsal view, although its hypostoma resembles unfurrowed ones of *Megalaspis*. The difference between *Paramegalaspis* and *Asaphellus* s. str. is in the part where the branching of the posterior into wings begins. Therefore so far as the hypostoma is concerned, *Asaphellus* may stand at about the crossroad whence the three subgenera do not go far astray.

(?) *Asaphellus lewisi*, n.sp.

PLATE XII, FIGS. 16, 17 (?), 18, AND 19

1883. *Asaphus* sp. Etheridge, Proc. Roy. Soc. Tasm. 1882 (1883) p. 156, pl. I, fig. 6.

1888. *Asaphus* sp. indet. Johnston, Syst. Acc. Geol. Tasm. pl. I, fig. 18.

*Description*:—Cephalon gently convex with a slightly concave border, glabella occupies three-fourths the cephalic length outlined by a shallow furrow; palpebral lobe located at a point one-third the distance from the posterior margin and opposed to each other at the glabellar contraction by which it is divided into a subovate anterior and triangular posterior parts; a medium tubercle found at a point in the posterior triangle; facial suture, isoteliform.

Pygidium semicircular, frontal margin broadly arcuate; axial lobe flat-topped, tapering backward and terminates at a blunt end; no furrows except one near the articulating margin; marginal border slightly concave.

*Observation*:—The collection contains a cast of hypostoma which is subquadrate, gently expanding forward. Both sides of the posterior outline are rounded. The lateral edge of the hypostoma is conspicuously elevated. Its central body is oval, behind which a crescent-shaped ridge is located. These elevations are clearly figured out by the furrow which is especially deep on the anterior and posterior sides of the posterior ridge delimiting maculae from the main body. The anterior wings may not be very large, insofar as can be judged from the aspect of their attachment.

*Comparison*:—A free cheek in fig. 17 belongs to an asaphid, but its specific determination is most uncertain, because I cannot trace the anterior course of the facial suture. It has a concave lateral border which narrows backward and hence I cannot determine whether the genal spine is unpreserved or really absent. Putting aside the dubious free cheek, the other parts of the carapace show most features characteristic of *Asaphellus*, namely, the isoteliform facial suture, unfurrowed glabella, tiny median tubercle, unfurrowed pygidium and concave borders on the cephalon and pygidium. The hypostoma belongs to the kind of *Asaphellus* s. str. Although the relative position of the organs may be more or less changed by the secondary distortion, the eye is located more posteriorly than is usual in *Asaphellus*, and further, the glabellar outline suggests the approach to *Megalaspis*. In Eastern and Southern Asia there are several Lower Ordovician asaphids which are allied to this species and they are *Isotelus stenocephalus* Mansuy, *Asaphus*

*gigas* Dekey var. *hupeiensis* Sun, *Megalaspis* aff. *hyorhina* Herz. von Leuchtenberg, *Ptychopyge thebawi* Reed, *Ptychopyge* (*Basilicus*) *titanica* Reed, *Asaphellus tomkolensis* Kobayashi, *Asaphellus* (aff.) *gyracanthus* Raymond *Asaphellus* (?) *coreanicus* Kobayashi, and so forth. The pygidium is fairly well segmented in the Burmese form but is obscure in others. In the posterior position of the eye the present species agrees with Sun's species. Mansuy's species agrees with the present species in the form of the axial lobe of the pygidium but differs from it in the position of the palpebral lobe. Although no one can tell what difference will be made out if their hypostomata are discovered, Mansuy's species and probably Sun's species belong to the same kind of Asaphid, as far as the dorsal shield is concerned.

Finally it is noted that Etheridge's *Asaphus* sp. in fig. 6, which was procured from the same locality with the present specimen, most probably belongs to this species so far as I can judge from his illustration.

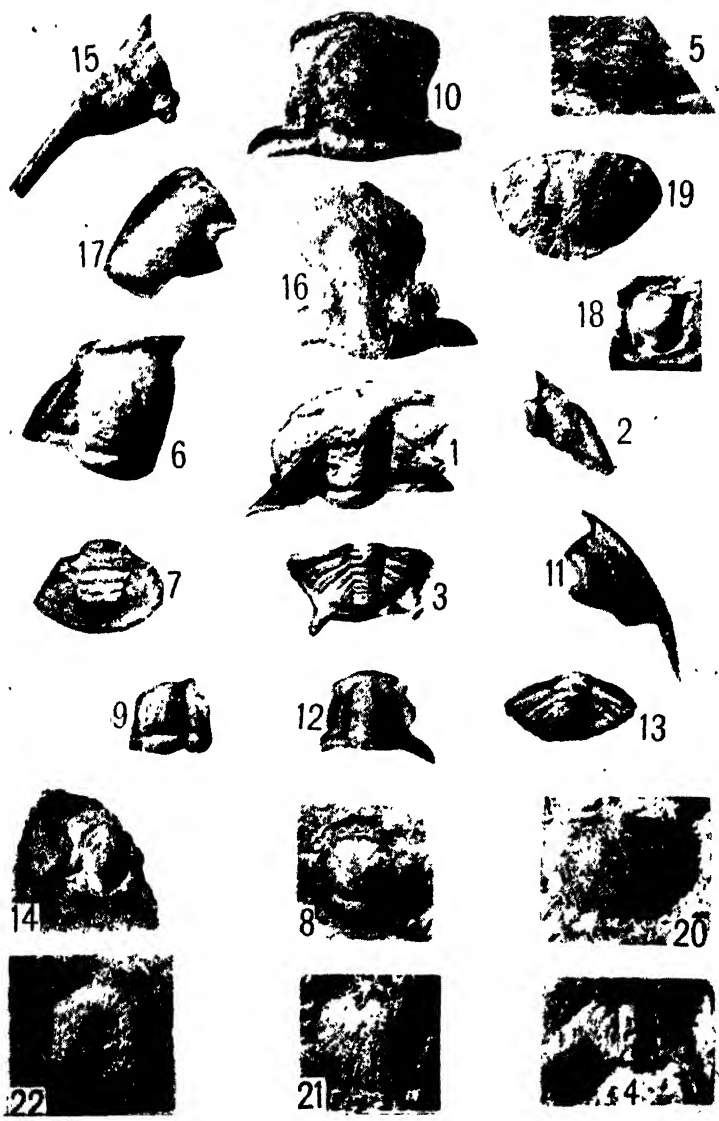
## REFERENCES

- CALLAWAY, C., 1877.—On a New Area of Upper Cambrian Rocks in South Shropshire with a Description of a New Fauna. *Q.J.G.S.* London vol. 33
- ENDO, R., 1935.—Additional Fossils from the Canadian and Ordovician Rocks of the Southern Part of Manchoukuo. *Sci. Rep. Tohoku Imp. Univ. Sec. Sci. (Geol.)* vol. 16, no. 4.
- ETHERIDGE, R., JR., 1883.—A Description of the Remains of Trilobites from the Lower Silurian Rocks of the Mersey River District, Tasmania. *Proc. Roy. Soc. Tas.*, 1882 (1883).
- , 1919.—Cambrian Trilobites of Australia and Tasmania. *Trans. Roy. Soc. South Australia*, vol. 43.
- HARRINGTON, H. J., 1938.—Sobre las Faunas del Ordoviciano Interior del Norte Argentino. *Revista del Museo de la Plata* (Nueva Ser.). Tom. 1, Sec. Palaeontol.
- JOHNSTON, R. M., 1888.—*Systematic Account of the Geology of Tasmania*
- KOBAYASHI, T., 1934.—The Cambro-Ordovician Formations and Faunas of South Chosen, Palaeontology Pt. 2, Lower Ordovician Faunas, *Jour. Fac. Sci. Imp. Univ. Tokyo*, Sec. 2, vol. 3, pt. 9.
- , 1936.—Notes on Some Ordovician Faunas of Tasmania in "Three Contributions to the Cambro-Ordovician Faunas". *Japan Jour. Geol. Geogr.* vol. 13.
- , 1937.—The Cambro-Ordovician Shelly Faunas of South America, *Jour. Fac. Sci. Imp. Univ. Tokyo*, Sec. 2, vol. 4, pt. 4.
- , 1938.—Upper Cambrian Fossils from British Columbia with a Discussion on the Isolate Occurrence of the so-called "Olenus" Beds of Mt. Jubilee, *Japan Jour. Geol. Geogr.* vol. 15.
- MANSUY, H., 1920.—Nouvelle Contribution à l'Étude des Faunes paléozoïques et mésozoïques de l'Annam septentrional, Région de Thanh-hoa, *Mém. Serv. géol. de l'Indochine*, vol. 7, fasc. 1.
- MATTHEW, G. F., 1903.—Report of the Cambrian Rocks of Cape Breton, *Geol. Surv. Canada*, No. 797.
- RAYMOND, P. E., 1910.—Notes on Ordovician Trilobites, 2, Asaphidae from the Beekmantown, Ann. *Carnegie Mus.* vol. 7, no. 1.
- , 1924.—New Upper Cambrian and Lower Ordovician Trilobites from Vermont, *Proc. Boston Soc. Nat. Hist.* vol. 37 No. 4.
- REED, F. R. COWPER, 1906.—The Lower Palaeozoic Fossils of the Northern Shan State, Burma, *Palaeontol. Indica*, n.s. vol. 2, Mem. no. 3.
- , 1915.—Supplementary Memoir on New Ordovician Silurian Fossils from the Northern Shan States, *Palaeontol. Indica*, n.s. vol. 6, Mem. no. 1.

- REED, F. R. COWPER, 1917.—Ordovician and Silurian Fossils from Yunnan, *Palaeontol. Indica*, n.s. vol. 6, Mem. no. 3.
- , 1918.—*Monograph of the British Ordovician and Silurian Bellerophonacea*, Pt. 2. (Palaeontogr. Soc.)
- , 1931.—A Review of the British Species of the Asaphidae, *Ann. Mag. Nat. Hist.* ser. 10, vol. 7.
- BALTER, J. W., 1966.—*A Monograph of British Trilobites*, (Palaeontogr. Soc.).
- SUN, Y. C., 1931.—Ordovician Trilobites of Central and Southern China, *Palaeontol. Sinica*, Ser. B., vol. 7, Fasc. 1.
- THORAL, M., 1935.—*Contribution à l'Étude paléontologique de l'Ordovicien inférieur de la Montagne Noire, etc.* Montpellier.
- ULRICH, E. O. IN WALCOTT, 1924.—Cambrian and Lower Ozarkian Trilobites, *Smiths. Misc. Coll.*, vol. 75, no. 2.

## PLATE XII

- FIGS. 1-3.—*Tasmanaspis stephensi* (Etheridge),  $\times 1\frac{1}{2}$ .
- FIG. 4.—Ditto,  $\times 3$ .
- FIG. 5.—*Prosopiacus* (?) *subquadratus*, n. sp.,  $\times 1$ .
- FIGS. 6-7.—*Carolinites bulbosa*, n. sp.,  $\times 3$ .
- FIGS. 8-9.—*Carolinites quadrata*, n. sp.,  $\times 2$ .
- FIGS. 10-11.—*Etheridgaspis carolinensis* (Etheridge),  $\times 2$ .
- FIGS. 12-13.—*Etheridgaspis johnstoni* (Etheridge),  $\times 2$ .
- FIG. 14.—Ditto,  $\times 1\frac{1}{2}$ .
- FIG. 15.—Free cheek gen. et sup. undet.,  $\times 2$ .
- FIG. 16.—*Asaphellus lewini*, n. sp.,  $\times 1$ .
- FIGS. 17-19.—Ditto,  $\times 1\frac{1}{2}$ .
- FIG. 20.—Brachiopod, gen. et sp. undet.,  $\times 1\frac{1}{2}$ .
- FIG. 21.—Ditto,  $\times 3$ .
- FIG. 22.—*Cryptolites* sp.,  $\times 2$ .







# \* Notes on the Blood System of the Marsupialia

By

JOSEPH PEARSON

(Read 13 November, 1939)

The following notes were made in the course of a study of the comparative anatomy of the Marsupialia. The heart and great vessels have been reserved for a future paper.

In all thirty-three specimens belonging to the following thirteen species have been dissected:—

- Dasyurus viverrinus* (Native Cat).
- Sarcophilus harrisii* (Tasmanian Devil).
- Isodon obesulus affinis* (Short-nosed Bandicoot).
- Perameles gunnii* (Tasmanian striped Bandicoot).
- Petaurus breviceps* (Lesser Flying Phalanger).
- Pseudocheirus convolutus* (Ring-tailed Phalanger).
- Trichosurus vulpecula fuliginosus* (Brush-tailed Phalanger).
- Phascolomys ursinus* (Island Wombat).
- Phascolomys ursinus tasmanicus* (Tasmanian Wombat).
- Bettongia cuniculus* (Tasmanian Bettong).
- Potorous tridactylus apicalis* (Long-nosed Rat Kangaroo).
- Thylogale billardieri* (Rufous Wallaby).
- Macropus tasmaniensis* (Forester Kangaroo).

## 1. ARTERIES ARISING FROM THE BASE OF THE AORTA

There is as much variation in the origin of these arteries in the Marsupials as there is throughout the entire Mammalia, and all stages exist from what may be regarded as a primitive condition to be found in *Phascolarctos*, in which the subclavians and common carotids of both sides arise independently, to the highly specialized condition found in *Petaurus breviceps* in which the four subsidiary arteries arise from the aorta through the medium of a common vessel.

In the following summary I have brought together the results of my own observations together with those of other workers.

### A. Four Arteries arising independently from the Aorta

This condition has been described by Sonntag (1921a) in *Phascolarctos cinereus* (Fig. 1).

### B. Three Arteries arising from the Aorta

- (a) Right subclavian and right common carotid connected with the aorta by the right innominate artery.

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\* This work has been carried out under the auspices of the Biological Survey of Tasmania. Most of the specimens which provided material for the present study were obtained by the Biological Survey.

*Bettongia cuniculus* (Pearson) (Fig. 3); *Phascolarctos cinereus* (Forbes, 1881; Sonntag, 1921b); *Petaurus breviceps* (Sonntag, 1921b); *Phascalomys ursinus* (Forbes, 1881; Sonntag, 1921b; Pearson).

In *Phascalomys* I have found one case in which the right subclavian arose so close to the base of the right common carotid artery (Fig. 2) that it was difficult to say whether this case belongs to Group A or is an intermediate condition between Group A and Group B (a).

- (b) The right subclavian artery arising independently, the two common carotids arising from an innominate.

*Dasyurus viverrinus* (Cunningham, 1882; Sonntag, 1921b; Pearson).

See Fig. 4.

### C. Two Arteries arising from the Aorta

- (a) An innominate from which are given off the right subclavian and the right and left common carotids, the left subclavian arising separately.

- (1) The innominate short, with the right subclavian arising near the junction of the innominate with the aorta (Fig. 5).

*Sarcophilus* (Pearson), *Dendrolagus* (Parsons, 1903) and *Notoryctes* (Sweet, 1904).

- (2) The innominate of medium length, with all three arteries arising from the innominate at the same level (Fig. 7).

*Macropus* (Sonntag, 1921b; Pearson); *Spilocoscus nudicaudatus* (Cunningham, 1882); *Phascolarctos* (Forbes, 1881; Sonntag, 1921b); *Dendrolagus* (Sonntag, 1921b); *Thylagale billardierii* (Pearson).

- (3) The innominate long, with the right subclavian given off some distance from the base, behind the origins of the right and left common carotids.

*Isodon obesulus affinis* (Pearson) Fig. 6; *Thylacinus* (Cunningham, 1882); *Trichosurus vulpecula fuliginosus* (Cunningham, 1882; Sonntag, 1921b; Pearson); *Didelphys cancrivora* (Sonntag, 1921b); *Petaurus australis* (Sonntag, 1921b).

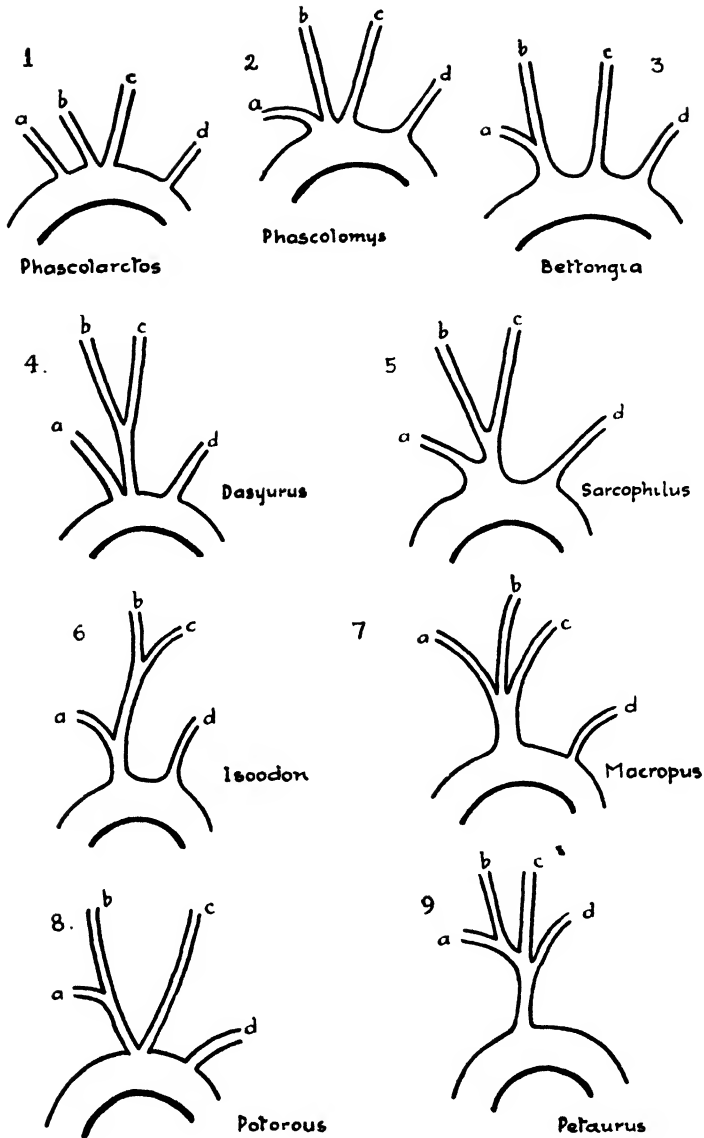
- (b) The right and left common carotids arising together from the aorta, the right subclavian arising from the right carotid. The left subclavian arising separately from the aorta.

*Potorous tridactylus apicalis* (Pearson, Fig. 8).

### D. One Artery arising from the Aorta

So far as I am aware this highly specialized condition is found only in *Petaurus breviceps* (Forbes, 1881; Pearson); (Fig. 9).

Parsons (1902) made a survey of the arrangement of the branches of the mammalian aortic arch, and he was able to show that there was considerable variation in these branches throughout the mammalian series. A careful study of his paper leads one to the conclusion that the method of branching of the vessels arising from the aortic arch is not correlated with the affinities of the various members of the group. From the analysis which has been given above it is obvious that the disposition of the branches of the aortic arch is of no value in determining the relationships and probable evolution of the various members of the Marsupialia. There is, in fact, just as much variation in the arrangement of these arteries within the single order Marsupialia as there is in the whole of the Mammalia.



ARRANGEMENT OF THE ARTERIES ARISING FROM THE BASE OF THE AORTA IN THE MARSUPIALIA

FIG. 1.—*Phascolarctos cinereus* (after Sonntag); FIG. 2—*Phascalomys ursinus*; FIG. 3—*Bettongia ornatus*; FIG. 4—*Dasyurus viverrinus*; FIG. 5—*Sarcophilus harrisi*; FIG. 6—*Isodon obesulus affinis*; FIG. 7—*Macropus tasmaniensis*; FIG. 8—*Potorous tridactylus apicalis*; FIG. 9—*Petaurus breviceps*.

a, right subclavian artery; b, right common carotid artery, c, left common carotid artery; d, left subclavian artery.

## 2. POSTERIOR ARTERIES

After giving rise to the arteries which have been dealt with above, the aorta makes a sudden turn to the left and runs immediately below the vertebral column to the posterior end of the body. In its anterior region the aorta gives off a series of paired intercostal arteries, each of which lies in an intercostal space immediately behind the corresponding intercostal vein (Fig. 10).

A short distance behind the diaphragm the coeliac artery gives off branches to the liver, pancreas, stomach and duodenum. Immediately behind the coeliac artery the mesenteric artery arises, generally near the level of the right renal

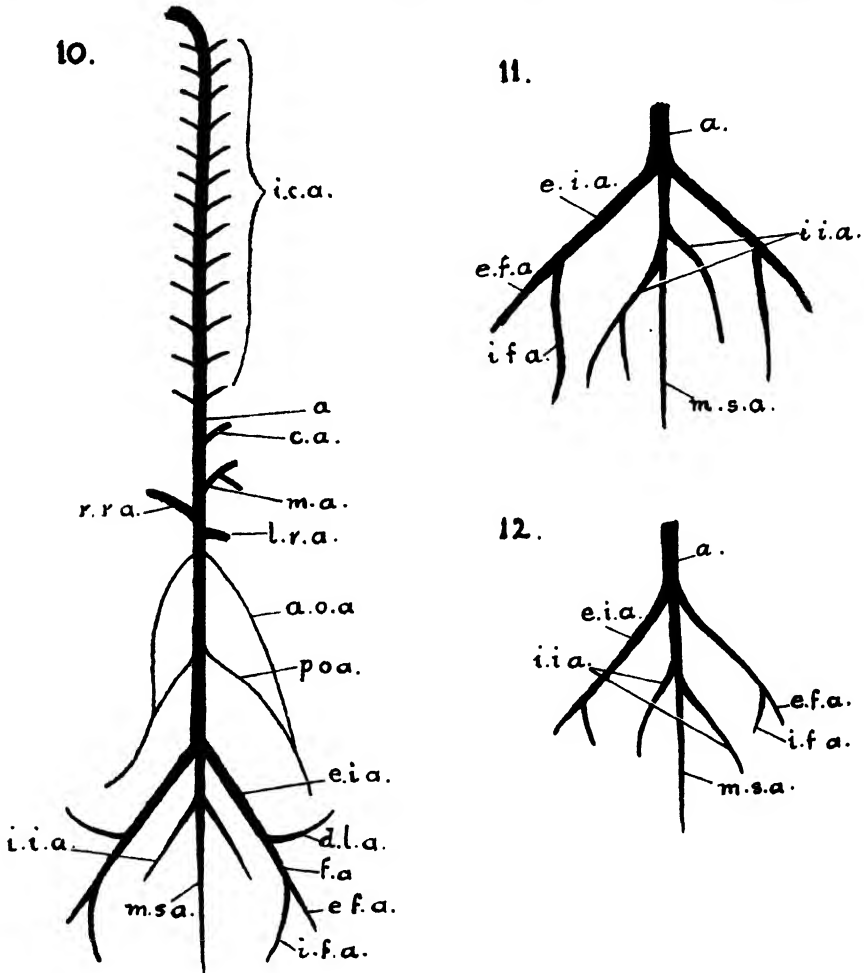


FIG. 10—Dorsal aorta and its branches in the Marsupialia; FIG. 11—Posterior arteries in *Phascolumys*; FIG. 12—Posterior arteries in *Trichosurus*.

a, aorta; a.o.a., anterior ovarian artery; c.a., coeliac artery; d.l.a., dorso-lumbar artery; e.i.a., external iliac artery; i.c.a., intercostal arteries; e.f.a., external femoral artery; f.a., femoral artery; i.f.a., internal femoral artery; i.i.a., internal iliac artery; i.l.a., ilio-lumbar artery; l.r.a., left renal artery; m.a., mesenteric artery; m.s.a., median sacral artery; p.o.a., posterior ovarian artery; r.r.a., right renal artery.

artery. The mesenteric artery divides almost immediately into the anterior mesenteric artery, which supplies the main parts of the intestine and spleen, and the posterior mesenteric artery, which supplies the rectum. This arrangement differs from that in the Monodelphia where the anterior and posterior mesenteric arteries usually arise separately from the aorta.

The spermatic (or ovarian) arteries consist of an anterior pair of vessels which arise from the aorta immediately behind the renal arteries, and a posterior pair which arise from the aorta about half way between the origin of the left renal artery and the point at which the aorta divides posteriorly into the two external iliac arteries. The anterior and posterior spermatics join and supply the reproductive organs. The two external iliac arteries arise from the posterior end of the aorta and immediately behind their point of origin a median artery is given off from which the two internal iliac arteries and the median sacral artery arise. This arrangement differs from that generally found in the higher Mammalia in which the external and internal iliac arteries arise from a common iliac artery. Each external iliac artery passes down the hind limb of its own side and divides into the external and internal femoral arteries. The internal iliac arteries supply blood to the pelvic regions and the bladder. The median sacral artery is continued into the tail as the caudal artery. The right and left internal iliaes are not always given off at the same level (Figs. 11 and 12).

### 3. ANTERIOR VENAE CAVAE

According to Forbes (1881) and Sonntag (1921b) and confirmed by my own dissections, *Petaurus breviceps* has a single anterior vena cava formed by the junction of the right and left innominate veins, a condition frequently found in the higher mammalia. With this single exception all marsupials which have been dissected have two anterior venae cavae, right and left respectively. Fig 13 gives the arrangement of the tributaries of the right anterior vena cava in *Phascolumys ursinus*, and, with minor variations, this arrangement holds good for all marsupials. In all cases the external jugular vein is the largest vessel returning blood from the head to the heart. The anterior jugular (thyroid) vein, which receives blood from the larynx and thyroid gland, and is connected with the sub-maxillary vein, is generally larger than the internal jugular vein, which runs alongside the common carotid artery. In *Dasyurus viverrinus*, however, the internal jugular is larger than the anterior jugular vein.

Each external jugular vein is made up of five principal branches, namely, the sub-maxillary vein, the anterior facial (external maxillary) vein, the posterior facial (internal maxillary) vein, the post-auricular, and the cephalic, which arises from the radial side of the fore limb.

The sub-maxillary vein runs transversely and receives blood from the sub-maxillary glands and from the region between the rami of the mandibles. It runs across the ventral and inner side of the masseter muscle (Fig. 14). The anterior facial vein passes across the ventral face of the masseter muscle and joins the posterior facial vein, which passes through the substance of the parotid gland. The common vein thus formed almost immediately receives the sub-maxillary vein on its inner and the post-auricular vein, from behind the ear, on the outer side. The above veins form the external jugular, which passes backward ventral to the insertion of the sterno-mastoid muscle and runs on the outer side of this muscle. It then receives the cephalic vein on its outer side and the anterior jugular vein and the internal jugular vein on its inner side. Immediately



in the case of the American marsupial *Didelphys* the azygos veins and the post-cardinals are present at the same time in an 8 mm. embryo. In this genus the azygos veins are apparently formed by the anastomosis of a series of lateral off-shoots of the postcardinals, and the two sets of veins remain connected for some time by a series of transverse vessels. Ultimately the postcardinals disappear and the left azygos grows considerably, while the right either disappears altogether or remains as an insignificant vessel, receiving veins from not more than five intercostal spaces.

Beddard (1907) describes an interesting condition in the newly-born South American rodent *Myopotamus*. In the thoracic region there were two vessels connected with the right precaval and one with the left precaval. In Beddard's opinion these represent a right and left postcardinal and a single right azygos.

It would appear that the homology and origin of the azygos veins vary in different mammals. Beddard suggests that the true azygos is always a single vein and that when right and left vessels are present they are either two post-cardinals or a single azygos and one persistent postcardinal. This, however, is not borne out by McClure's investigations into the venous system of *Didelphys*, and the investigations of other workers show that there is apparently no hard and fast rule for the development of the azygos veins, but that in most cases they are either the actual vestiges of the postcardinal or are derivatives of them. The problem of the homology of this system of veins presents many difficulties, and it is probable that the development of the azygos system is not uniform throughout the Mammalia.

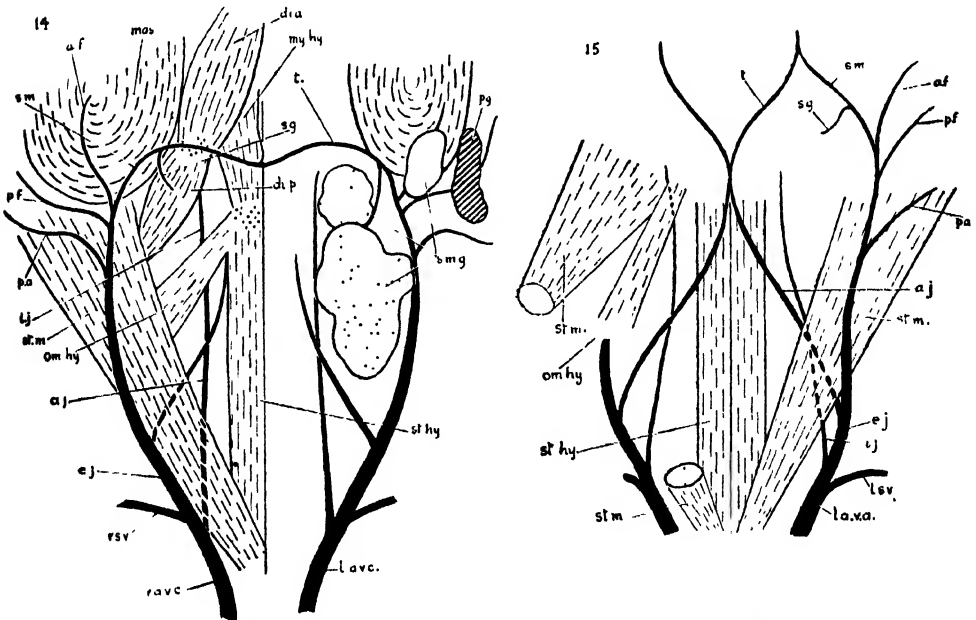


FIG. 14.—*Dasyurus viverrinus*. Veins of the neck. On the right side the submaxillary and parotid glands have been removed. On the left side the muscles are not shown; FIG 15.—*Sarcophilus harrisi*. Veins of the neck. On the right side the sterno-mastoid muscle has been cut.

dia., digastric muscle (anterior part); di.p., digastric muscle (posterior part); mas., masseter muscle; my.hy., mylo-hyoid muscle; om.hy., omo-hyoid muscle; p.g., parotid gland; s.m.g., sub-maxillary glands; st.hy., sterno-hyoid muscle; st.m., sterno-mastoid muscle (Other references as in fig 13.)



The azygos veins are variable in the Mammalia, and occur either as paired vessels returning blood from the intercostal spaces to the anterior venae cavae, as in many Marsupials, Rodents, Insectivores and Artiodactyles, or as a single vessel returning blood from the intercostal spaces of both sides, the right azygos in some Marsupials, Carnivora, Edentates, Lemurs and Primates, and the left in some Marsupials, Rodents and Artiodactyles (Beddard, 1907, p. 222).

Within the Order Marsupialia, the azygos veins show a great variety of arrangement. Milne-Edwards characterized the group as having two azygos veins equally developed and the great comparative anatomist, Richard Owen (1841), concurred in stating that the azygos veins in the Marsupialia 'retain their original separation and symmetry.' It would be more correct to say, however, that although the azygos system in the marsupials is based upon the essential plan of the primitive posterior cardinals, more often than not the original symmetry has been lost and all conditions may be found from the double azygos of *Phascolomys* to the condition found in *Didelphys* where the right azygos is usually absent.

With the exception of *Phascolomys*, which has 15 pairs of ribs, most marsupials have 13 pairs, and the intercostal veins run immediately posterior to the ribs alongside and anterior to the corresponding intercostal artery. Generally speaking, the azygos system is linked up with all the intercostal veins except the first two or three pairs. Usually the left azygos enters the left precava slightly posterior to the level of the entry of the right azygos into the right precava. The oesophageal vein enters either the right or left azygos vein (Fig. 16).

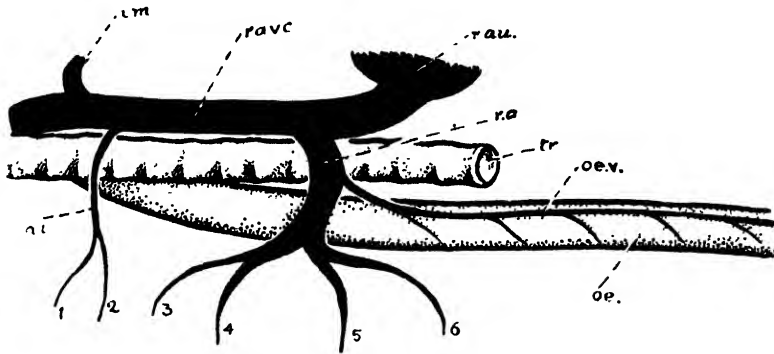


FIG. 16- *Sarcophilus harrisi*. Lateral view of azygos vein of right side (the complete system is seen in fig. 26).

a.t., right anterior intercostal vein receiving the veins from the 1st and 2nd intercostal spaces; i.m., internal mammary (sternal) vein; oe., oesophagus, oe.v., oesophageal vein; r.a., right azygos vein; r.au., right auricle, r.a.v.c., right anterior vena cava; tr., trachea.

In the marsupials, the azygos system is rarely connected with the veins of the first two intercostal spaces.\* The arrangement of these anterior intercostal veins would appear to vary considerably in different forms. In *Didelphys* McClure (1903) has shown that the blood from the first two intercostal spaces is collected by the superficial superior intercostal veins which open into the anterior venae cavae. He has also shown that these veins anastomose with the deep superior intercostal veins and as Beddard (1907) has pointed out, these latter veins may, in some cases, be the sole means by which the contents of the first two intercostal veins are returned to the heart. There is still a further possibility. The right and left sternal (internal mammary) veins receive blood from the

\* In figs. 17-27 which deal with the azygos system the first two pairs of intercostal veins are not shown.

ventral portion of the intercostal spaces and open into the anterior vena cava and possibly in some cases this may be the only means by which the blood from the anterior intercostals is returned to the heart. Very rarely the anterior intercostals actually open into the azygos. In some marsupials which I have dissected it has been difficult to trace the two anterior intercostal veins and occasionally these vessels enter the anterior vena cava by a common vein which does not appear to have any relation to the vessels mentioned above.

For instance, in *Thylacinus* Cunningham (1882) showed that the first three intercostal veins of the right side open into the right anterior vena cava by a single vein which is distinct from the azygos. Similarly on the left side where there is no azygos the first three intercostal veins open into the left anterior vena cava by a single vessel. I have found a comparable state of things in *Sarcophilus*. Here the blood from the first two intercostal spaces opens into the anterior vena cava of each side by a single vein which is not connected with the azygos veins (Fig. 16) which in this form are present on both sides. A similar arrangement has also been noted by me in *Perameles gunnii*. The veins receiving the anterior intercostals in the above instances do not appear to be either the superficial or deep superior intercostals.

McClure (1903) and Beddard (1907) have summarized the findings of previous observers with regard to the disposition of the azygos system in Marsupials.

McClure considers that the azygos system may be arranged in three different ways, viz.,

1. Right and left azygos veins equally developed.
2. Right azygos vein only developed.
3. Left azygos vein only developed.

This statement of the case is misleading, as it suggests a clear cut separation into three distinct types, a distinction which does not exist, and no allowance is made for intermediate types between 1 and 2 and between 1 and 3. If a sufficiently large number of specimens of each marsupial species were examined I do not think that there are many (if any) species in which traces of both right and left azygos veins are not sometimes present.

Beddard's interpretation is more satisfactory in this respect as he includes these intermediate types and recognizes five different arrangements of the azygos system, viz.,

1. Right and left azygos, equal or nearly equal.
2. Large right azygos, small left azygos.
3. Azygos on right side only.
4. Large left azygos, small right azygos.
5. Azygos on left side only.

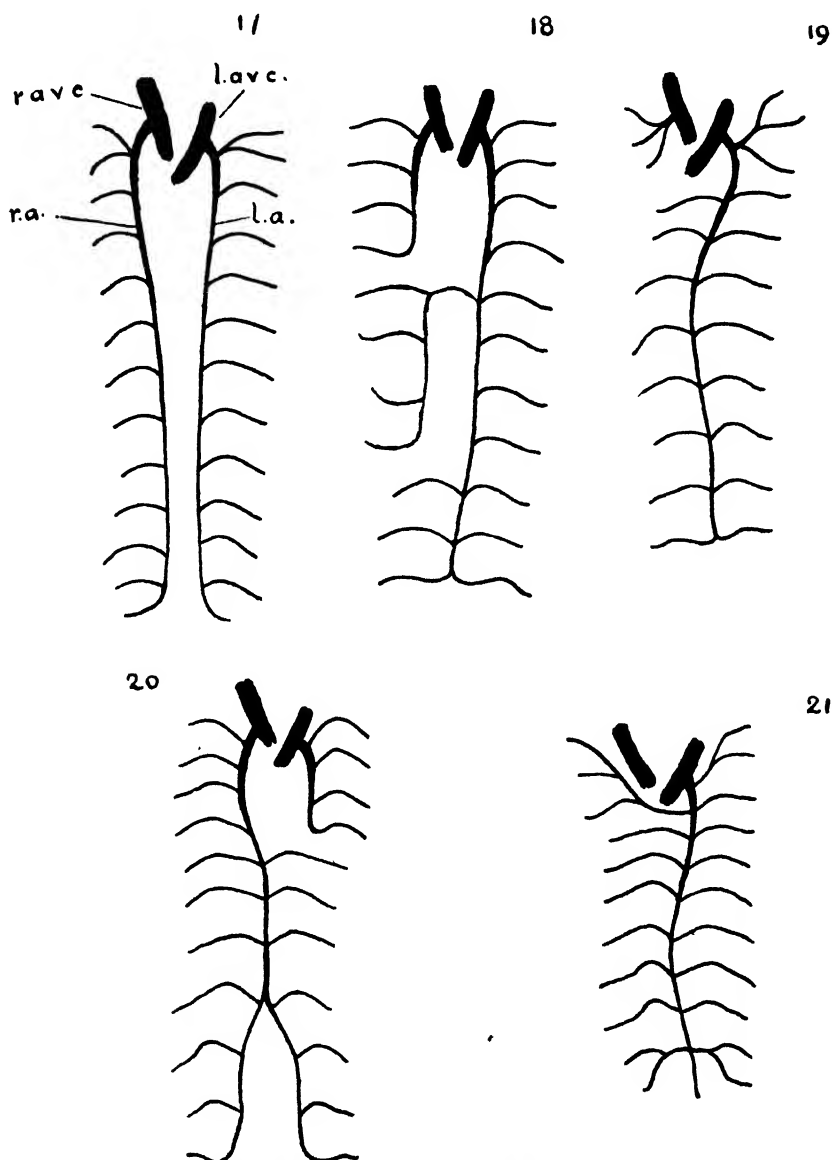
But even Beddard's classification does not meet all cases, although it may be regarded as being sufficiently true as a general statement of the case.

The following is a statement of the results of dissections of the azygos system in the course of the present investigations. If these are added to Beddard's list, a fairly complete knowledge of the arrangement of the azygos system in the Marsupials can be obtained:—

#### 1. Right and left Azygos Veins equally developed

Here the intercostals of each side drain into the azygos of the same side. I have found this arrangement consistent in six specimens of *Phascalomys urinus* which I have examined (Fig 17). Forbes (1881), however, gives a case in which the right azygos of *Phascalomys* was extremely small and most of the intercostal veins opened into the left. There was, however, a small connexion between the

posterior intercostal vein opening into the right azygos and the anterior intercostal of the right side which opened into the left azygos and this connexion probably indicated a relic of the right azygos.



TYPES OF AZYGOS SYSTEM IN THE MARSUPIALIA

FIG. 17.—*Phasciolumys*; FIG. 18.—*Potorous*; FIG. 19.—*Pseudochairus*; FIG. 20.—*Thylogale*; FIG. 21.—*Isodon*.

*l.a.*, left azygos vein; *l.a.v.c.*, left anterior vena cava; *r.a.*, right azygos vein; *r.a.v.c.*, right anterior vena cava. (The lettering in fig. 17 applies to all five figures.)

In a specimen of *Bettongia cuniculus* which I dissected both right and left azygos veins were fully developed though the right was thinner than the left.

Out of three specimens of *Sarcophilus harrisi* examined by me one came under the present category (Fig. 25) though in the others the right azygos was poorly developed.

## 2. Left Azygos well developed. Right Azygos relatively small

In this category the left azygos receives not only the left intercostal veins but also the posterior intercostal veins of the right side (Figs. 18, 19).

In one example of *Dasyurus viverrinus* the right azygos was almost as long as the left and only the three posterior intercostals of the right side drained into the left azygos (Fig. 22.)

In specimens of the following species I found the right azygos small and draining only two to four intercostal spaces.

*Dasyurus viverrinus* (Figs. 23, 24).

*Perameles gunnii*.

*Potorous tridactylus apicalis* (Fig. 18).

*Sarcophilus harrisi* (Figs. 26, 27).

*Trichosurus vulpecula fuliginosus*.

*Pseudocheirus convolutor* (Fig. 19).

## 3. Left Azygos well developed. Right Azygos absent.

Here the intercostal veins of both sides drain into the left azygos.

*Isodon obesulus affinis* (Fig. 21).

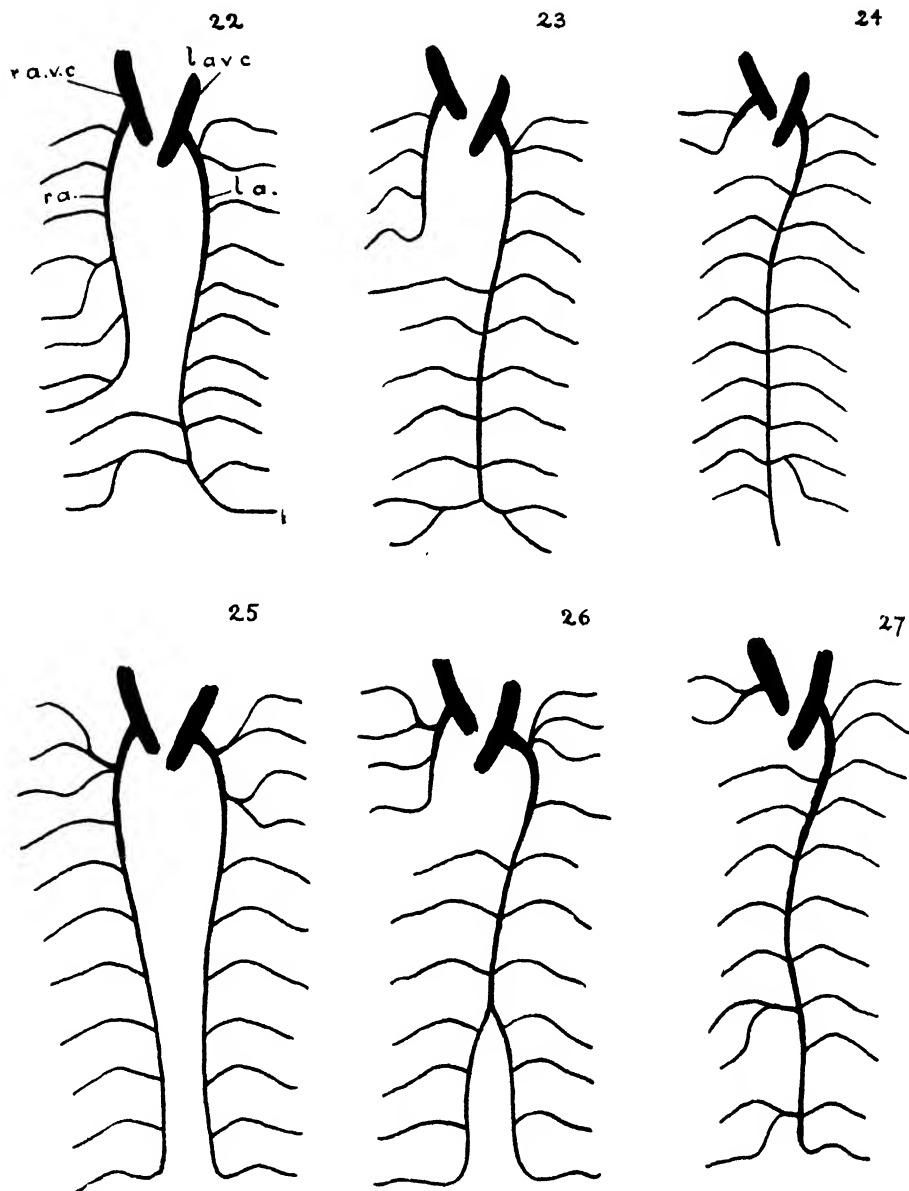
## 4. Right Azygos well developed. Left Azygos with few intercostals

This is a rare and exceptional condition in the Marsupials. It has been recorded by Cunningham (1882) in *Thylacinus* and by Parsons (1896) and Beddard (1895, 1907) in some of the Macropodinae. I have found it in *Thylogale billardieri* (Fig. 20).

It is clear from the above lists that there is considerable variability in the disposition of the azygos system in the Marsupials. Not only do related species show differences, but even within the limits of a single species there may be almost every type of arrangement. For example, in *Dasyurus viverrinus* Beddard (1907) has given a case which had equal right and left azygos veins, and in the course of the present investigation dissections of this species have shown that usually the left azygos predominates and that the right azygos may vary from having two intercostal veins to as many as eight (Figs. 22, 23, 24). Cunningham (1882) and Beddard (1907) have recorded instances in which the right azygos was entirely wanting in this species. Again in *Sarcophilus* I have found a considerable variation in the arrangement of the azygos system from two complete azygos veins to a condition in which the right azygos vein is reduced and receives only two intercostal veins while the left azygos is predominant (Figs 25, 26, 27). In *Thylacinus* there appears to be considerable variation as Cunningham (1882) found the left azygos absent. On the other hand Beddard (1907) stated that the left azygos predominates and the right azygos supplies only four intercostal spaces.

Having regard to this wide range of variability it would be unwise to attach too much importance to the azygos system as a basis of classification or as a means of indicating relationships. Beddard (1907) was inclined to regard this system as indicating relationships and affinities though he added the qualification that this indication was given only in a general way.

The condition in which both azygos veins are equally well developed may be regarded as primitive, nevertheless *Didelphys*, which, according to Bensley (1903) represents the nearest living approach to a primitive marsupial type, shows



## VARIATION IN THE ARRANGEMENT OF THE AZYGOS SYSTEM

FIGS. 22-24—*Dasyurus viverrinus* FIGS. 25-27—*Sarcophilus harrisii*.

(The lettering in fig. 22 applies to all six figures. References as in figs. 17-20.)

a very highly specialized condition in usually having no vestige of the right azygos. On the other hand, the wombat and some of the kangaroos sometimes show the primitive arrangement, though these animals are regarded as being highly specialized marsupials. A careful examination of McClure's and Beddard's lists, together with those cases which are given in the present paper, shows that the azygos veins in the marsupials give no reliable indication of the affinities of the various members of the order. I cannot agree, therefore, with Beddard (1907, p. 219) when he says that 'the division of the marsupials into Diprotodont and Polyprotodont is justified by the condition of the azygos veins,' and I do not think there is much in his contention that 'in the Diprotodont division there is a much greater tendency for the two azygos veins to persist than among the Polyprotodonts'. As I have shown above *Sarcophilus* and *Dasyurus* (both Polyprotodonts) show all stages between a complete double system of azygos veins and a predominant left azygos vein. The fact is that in the Marsupialia the azygos system is of little value in determining relationships.

McClure (1903) was of opinion that the single azygos is the rule in marsupials and that when the right and left are present this condition may be regarded as a variation. My own investigations do not confirm this. On the contrary I consider that the double azygos is typical of the marsupials, though frequently one, generally the left, is much more highly developed than the other, as for example, in *Trichosurus vulpecula fuliginosus* where the right azygos is very small and receives blood from only three intercostal spaces, or in *Thylogale billardieri* where the right azygos predominates. Milne-Edwards and Owen erred in the opposite direction in stating that the two azygos veins in the marsupials were equally developed and symmetrical.

Our present knowledge of the arrangement of the azygos system in the Marsupials may be stated as follows—normally, right and left azygos veins are present, usually, however, one is larger than the other, and in such cases it is more common to find the left azygos vein the predominant one. The arrangement of the azygos system is not always constant even within the limits of a single species, and a comparison of the arrangement of this system in different species of marsupials rarely helps in assessing the relationships of the members of the group.

##### 5. The Posterior Veins.

The posterior vena cava receives the blood from the posterior region of the body and alimentary canal, and returns it to the right auricle. As in the higher mammals the veins from the alimentary canal unite into the hepatic portal vein which breaks up in the liver. From the liver the blood is collected by the hepatic veins which enter the posterior vena cava.

Posterior to this the posterior vena cava receives blood from the hind limbs, the pelvic region, the reproductive organs, kidneys and lumbar region. It is important to note that the marsupials differ from the higher mammals in the manner in which the posterior vena cava lies completely ventral to the aorta. The only exception to this rule would appear to be *Schoinobates volans* (= *Petaurus taguanoides*) in which, according to Hochstetter, the aorta lies ventral to the posterior vena cava as is the case in the higher mammalia.

Beddard (1909) has discussed at some length the arrangement of the spermatik (or ovarian) veins in Marsupials which show considerable variation. The essential arrangement is shown in *Thylogale* (Fig. 28) and *Sarcophilus* (Fig. 31) where the ovarian vein from each ovary receives the uterine vein. About the level of the beginning of the posterior vena cava each ovarian vein divides into an

inner posterior ovarian vein, which joins the posterior vena cava with its fellow from the other side, and an outer anterior ovarian vein which enters the renal vein.

McClure (1903) has dealt very fully with the numerous variations which are to be found in the arrangement of the posterior tributaries of the posterior vena cava in *Didelphys*.

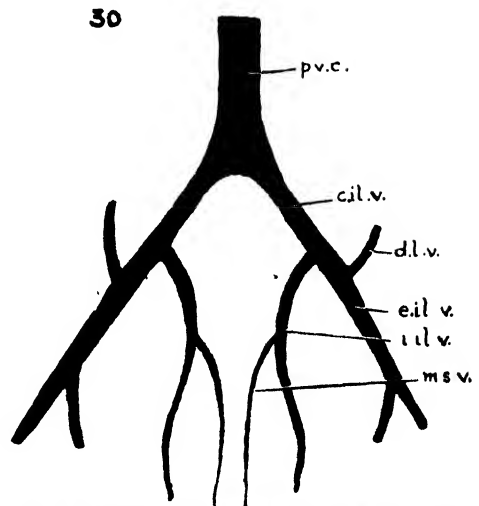
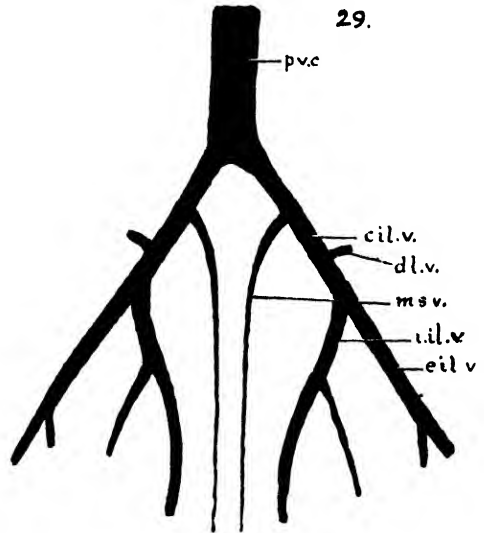
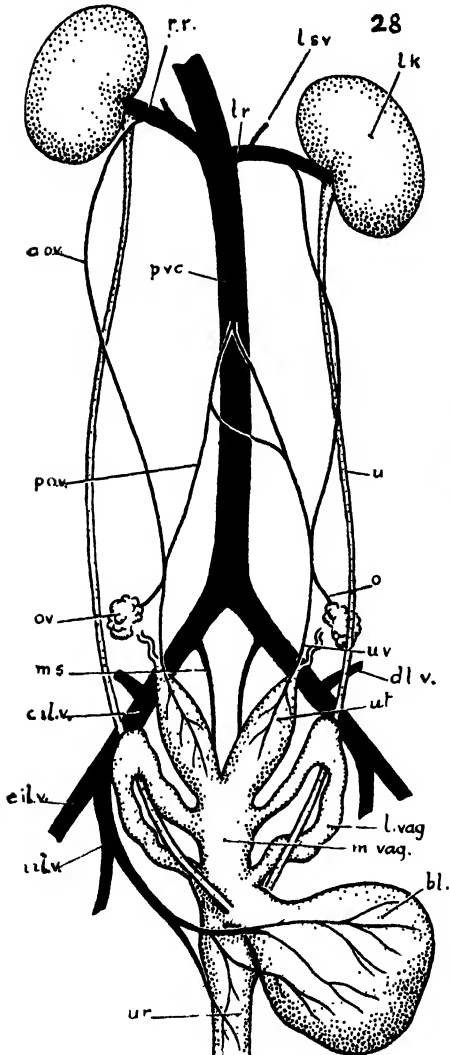


FIG. 28.—*Thylogale billardieri*. Veins of the urogenital system connected with the posterior vena cava. FIG. 29.—*Dasyurus viverrinus*. Posterior veins. FIG. 30.—*Phascolomys ursinus*. Posterior veins.

a.o., anterior ovarian vein; bl., bladder; c.il.v., common iliac vein; d.l.v., dorso-lumbar vein; e.il.v., external iliac vein; i.il.v., internal iliac vein; l.k., left kidney; l.r.v., left renal vein; l.s.v., left supra-renal vein; l.vag., lateral vaginal canal; m.s.v., median sacral vein; m.vag., median vagina; o., ovarian vein; ov., ovary; p.o., posterior ovarian vein; p.v.c., posterior vena cava; r.r.v., right renal vein; u., ureter; ur., urethra; u.f., uterus, u.v., uterine vein.

In the course of the present investigation it has been found that there are two main plans upon which the affluents of the posterior vena cava are formed.

(1) The internal Iliac Veins remain distinct from the Median Sacral (Caudal) Veins

This condition is found in *Thylogale billardieri* (Fig. 28), *Sarcophilus harrisii* (Fig. 31), *Perameles gunnii*, and *Dasyurus viverrinus*.

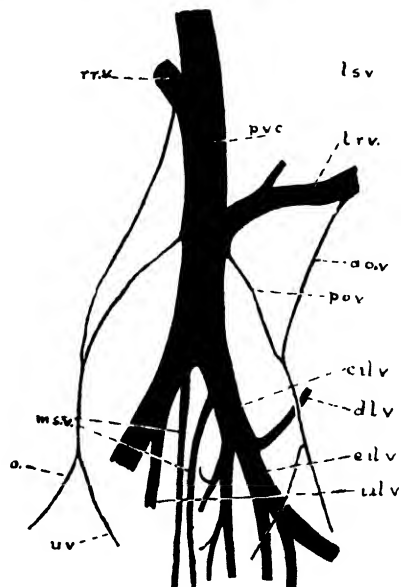


FIG. 31—*Sarcophilus harrisii*.—posterior vena cava and its branches.

(References as in figs 28-30.)

In this type the two median sacral veins start in the tail and run along the ventral side of the sacrum, one on each side of the median sacral artery and finally open into the common iliac vein. Each internal iliac vein returning blood from the bladder and pelvic region joins with the external iliac (femoral) vein of its own side to form the common iliac vein which joins with a similar vein of the opposite side to form the posterior vena cava (Fig. 29).

(2) The Median Sacral Veins join the Internal Iliacs

This condition is found in *Phascolumys ursinus* and *Trichosurus vulpecula fuliginosus*.

Here the two median sacral veins run forward on either side of the median sacral artery and each opens into the internal iliac vein of its own side. The internal iliac vein then joins the external iliac vein to form the common iliac vein. The two common iliac veins unite to form the posterior vena cava (Fig. 30).

If the posterior veins are as variable in other marsupials as they are in *Didelphys* it is not likely that the two types given above may be found in the same species.

#### SUMMARY

One of the objects of the investigation was to ascertain if the arrangement of the blood system in the Marsupialia threw any light upon the vexed question of the relationships of the major divisions of the group as well as upon the affinities of the group as a whole.



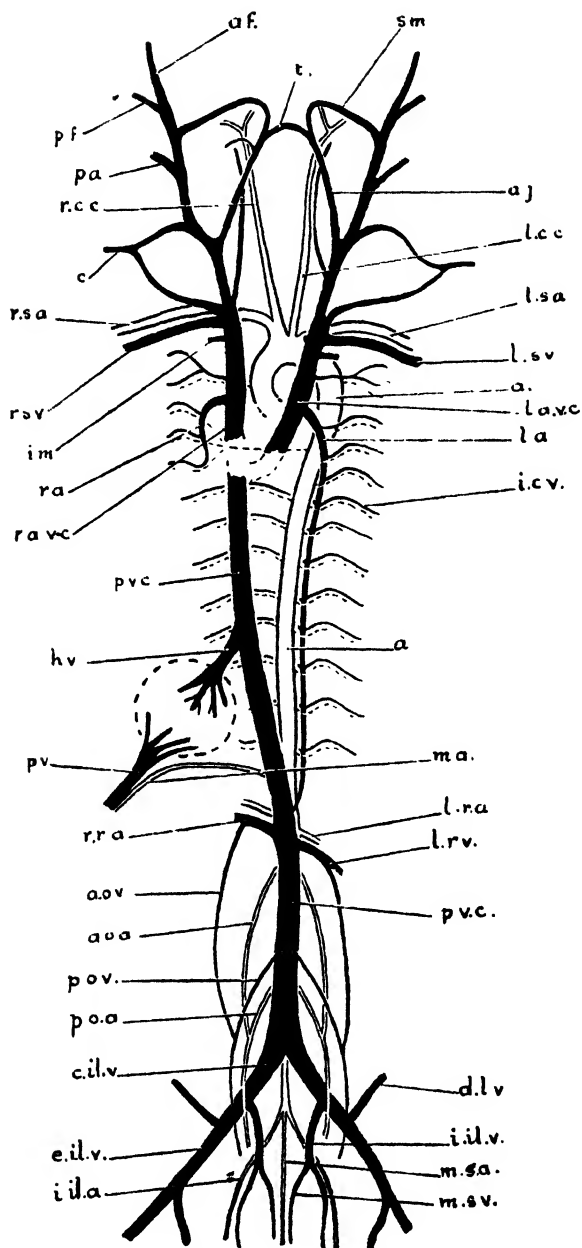


FIG. 32—Generalized diagram of blood system of a marsupial. (The veins are shown black, the arteries as double lines. The intercostal arteries are shown as dotted lines.)

a.v. = hepatic vein; p.v. = portal vein; l.c.v. = intercostal vein.

(Other references as in previous figures.)

Parsons (1902) has analyzed the arrangement of the branches of the aortic arch throughout the Mammalia and has shown that it is very variable, and, further, has made it clear that no specific arrangement characterizes any particular Order of Mammals. This same variability is to be seen within the Marsupialia which, incidentally, contains all the variations instanced by Parsons for the whole of the Mammalia.

With one exception (*Petaurus breviceps*) the marsupials retain the right and left anterior venae cavae derived from the primitive anterior cardinal veins, a character which they share with many Monodelphids.

Beddard (1907) made a comprehensive analysis of the azygos system in the Mammalia in which the system shows considerable variation. McClure (1903), Beddard (1907), and the present writer have shown that this system is very variable within the Marsupialia and in the present paper evidence has been submitted to show that considerable variation may exist even within the limits of a single species. Broadly speaking, the marsupial azygos system may be regarded as being more primitive than that of the higher mammals, because it shows more consistently than in the latter the presence of the primitive right and left branches, though usually the left is more highly developed than the right. Occasionally one side may be missing altogether, but I regard this as being abnormal.

The analysis given in this paper makes it clear that the blood system of the marsupials differs in no fundamental respect from that of the Monodelphia, where considerable variation is to be found.

For what it is worth the evidence of the marsupial blood system points to the fact that the Didelphia and Monodelphia have arisen from a common stock in which there were two anterior venae cavae and two azygos veins.

With the exception of Fig. 1 all the illustrations are original and were redrawn for publication by Capt. D. Colbron Pearse of the Tasmanian Museum and Art Gallery.

## REFERENCES

- BEDDARD, F. E., 1895.—On the visceral anatomy and Brain of *Dendrolagus bennetti*. *Proc. Zool. Soc.*, 1895, pp. 131-137.
- , 1907.—On the Azygos veins in the Mammalia. *Proc. Zool. Soc.* 1907, pp. 181-223
- , 1909.—On the Postcaval vein and its branches in certain Mammals. *Proc. Zool. Soc.* 1909, pp. 496-526.
- BENSLEY, B. A., 1903.—On the Evolution of the Australian Marsupialia with remarks on the relationships of the Marsupials in general. *Trans. Linn. Soc. Lond.* (2), IX, Part 3, pp. 83-217.
- CUNNINGHAM, D. J., 1882.—Report on some points in the Anatomy of the Thylacine (*Thylacinus cynocephalus*), Cuscus (*Phalangista maculata*), and Phascogale (*Phascogale calura*). *Zoological Reports of the voyage of H.M.S. "Challenger"*, vol. 5, Part XVI
- FORBES, W. A., 1881.—On some points in the anatomy of the Koala. *Proc. Zool. Soc.* 1881, pp. 180-195.
- MCCLURE, C. F. W., 1903.—A Contribution to the Anatomy and Development of the venous system of *Didelphys marsupialis* (I.), Part I. Anatomy. *Amer. Journ. Anat.*, vol. 2, n. 3, pp. 371-404.
- , 1906.—Part II. Development. *Amer. Journ. Anat.*, vol. 5, n. 2, pp. 163-226.
- OWEN, R., 1841.—Marsupialia from the *Cyclopaedia of Anatomy and Physiology*.

- PARSONS, F. G., 1896.—On the anatomy of *Petrogale xanthopus* compared with that of other Kangaroos. *Proc. Zool. Soc.*, 1896, pp. 683-714.
- , 1902.—On the arrangement of the branches of the mammalian aortic arch. *Journ. Anat. and Physiology*, XXXVI, pp. 389-399.
- , 1903.—On the Anatomy of the Pig-footed Bandicoot (*Chaeropus castanotis*). *Journ. Linn. Soc. Lond. (Zool.)* 29, no. 188, pp. 64-80.
- SONNTAG, C. F., 1921a.—Comparative anatomy of the Koala (*Phascolarctos cinereus*) and Vulpine Phalanger (*Trichosurus vulpecula*). *Proc. Zool. Soc.*, 1921, pp. 547-577.
- , 1921b.—Contribution to the visceral Anatomy and Myology of the Marsupialia. *Proc. Zool. Soc.*, 1921, pp. 851-882.
- SWEET, G., 1904.—Contribution to our knowledge of the Anatomy of *Notoryctes typhlops* Stirling. *Proc. R.S. Vict.*, 17, pp. 76-111.

## Record of *Glossopteris* from Cygnet

By

A. N. LEWIS, LL.D.

### PLATE XIII

(Read 13th November, 1939)

Plate XIII is a photograph of a small frond of *Glossopteris* from the Cygnet coal measures, recorded as confirming R. M. Johnston's observations.

These coal measures have been described by Johnston (1888), Twelvetrees (1902) and Reid (1922). Johnston records *Vertebraria* and 'a dwarf form of *Gangamopteris* probably identical with *G. spathulata* (M'Coy)'. In Plate X figures 4-8 he illustrates specimens from Adventure Bay.

On several occasions I have made as thorough a search as possible for fossils in the Cygnet coal seams without identifiable result except for fragments of *Vertebraria*. The fossil here indicated was found at 'Heaney's Mine' (Reid, 1922, p. 145) about 2 inches below the floor of the coal seam.

From the examination in the field I feel much doubt whether these coal measures should not be grouped with the Springs sandstone series rather than with the permian marine mudstones. Rocks of the Fern Tree stage underlie the coal measures but the marine series ends regularly and abruptly. The coal measures appear to me to be the base of the Springs sandstones as developed in the area and to merge gently upwards into this series. The stratigraphical break occurs at the top of the marine mudstones, not at the top of the coal measures.

The finding of this fossil, therefore, becomes of great interest. It has been submitted to Dr. A. B. Walkom who pronounces it to be definitely a *Glossopteris* but unfortunately not sufficiently well preserved to be certain of its species. It appears to me to be identical with Johnston's *Gangamopteris* from Adventure Bay. A fragment of *Vertebraria* occurs in the same piece of rock (at right angles to the bedding planes) and a section is discernible just above the leaf in the plate accompanying this paper. It is generally accepted that the Adventure Bay and Cygnet coal measures are as similar as those isolated coal basins ever are (see Johnston 1888 pp. 142-144). I consider that these coal measures should be regarded as forming the base or, in time, the earliest phase of the freshwater sandstone series.

Johnston's determination of *Gangamopteris spathulata* (M'Coy) should be corrected to *Glossopteris* sp. Both this fossil and Johnston's discoveries are small forms. Their prevalence over two separated areas leads to the impression that these are a dwarf or decadent form and not merely small specimens. It would be wrong to group them with *Gangamopteris spathulata* (M'Coy) as this is probably quite a distinct plant which Johnston, working on poorer material, has confused.

The fossil in question and, hence, Johnston's *Gangamopteris spathulata* (M'Coy), can only be called *Glossopteris* sp. until a specimen sufficiently well preserved for description is found.

It appears that the *Glossopteris* flora, in a decadent phase, persisted to the time of or immediately preceding the deposition of the Springs sandstone. No marked time interval between this and the Fern Tree stage of the Upper Permian Marine Mudstone is discernible here or elsewhere in Southern Tasmania. Only a little higher (some 700 feet) in the Springs Sandstones are found terrestrial fossils assigned to Upper Triassic (Rhaetic) age (Walkom 1926, p. 68). Only a little lower (again some 700 feet), shell fossils assigned to the Upper Permian are to be found. The Fern Tree stage and Springs stage averaging some 1400-1500 feet in thickness represent in Tasmania the time interval between the Upper Permian and the Upper Triassic, and no material disconformity has been discovered in the series. It appears therefore that the inclusion of this dwarf form of *Glossopteris* is hardly sufficient to assign these coal measures definitely to a Permian age and, on the other hand, the base, at least, of the Ross sandstones should probably be dated as very low in the Triassic. A considerable time interval covered by the series mentioned is evident and much resorting on a very stable terrain is indicated.

#### REFERENCES

- JOHNSTON, R. M., 1888.—*Geology of Tasmania*.  
REID, A. M., 1922.—Coal Resources of Tasmania. *Geol. Surv. Min. Resources* No. 8, Ch. VI (2).  
TWELVETREES, W. H., 1902.—Report on Gold and Coal at Port Cygnet. *Sec. for Mines Rep.*, 1901-1902.  
WALKOM, A. B., 1926.—Notes on some Tasmanian Mesozoic Plants, pt. II. *Pap. Roy. Soc. Tas.*, 1925 (1926.)



*Glossopterus* sp. from Cygnet. Natural size.



# The Vegetation of Mt. Wellington, Tasmania The Plant Communities and a Census of the Plants

By

D. MARTIN, B.Sc.

PLATES XIV, XV, XVI

(Read 13th November, 1939)

## INTRODUCTION

In this paper a description is given of the vegetation of an area approximately five miles square (approx. Lat.  $42^{\circ} 54'$ ; Long.  $147^{\circ} 17'$ ) lying west of Hobart and including all the Mt. Wellington Park Reserve and part of the Hobart City Water Reserve. These have been resumed since 1906, but before that time were commercially exploited and all the millable timber removed from the lower slopes. Since the creation of these reserves there has been some regeneration, but owing to frequent and often devastating bush fires the original appearance of much of the vegetation has been changed considerably. However, the higher parts are sufficiently untouched and the original composition of the lower parts clear enough to present a picture of the relationships between the various communities.

The plant cover of this area is practically pure Eucalyptus forest formation, covering a vertical range from sea level to 4000 feet. It gives an opportunity of studying the relation of the Eucalyptus forest formation to altitude and climatic and edaphic factors towards the most southerly part of its distribution. The relative dryness of the area has prevented the development of sub-antarctic rain forest and has modified the Austral-Montane formation considerably. A study of this region therefore forms a preliminary step in the study of these formations in Tasmania and helps to extend southwards the study of the montane vegetation of eastern Australia begun by Brough, McLuckie and Petrie (1924) at Mt. Wilson, McLuckie and Petrie (1927) at Kosciusko and Fraser and Vickery (1937-9) at Barrington Tops. Within Tasmania a comparison with the vegetation of Cradle Mt., where conditions are colder and wetter than at Mt. Wellington, can be made and the descriptions of the latter area by Gibbs (1920) and Beadle (1935) extended.

**Physiography.** (See Map.) The area forms the eastern end of an E-W range about 20 miles long, which rises to 4000 ft. in several places and forms the watershed between the lower courses of the Derwent and Huon Rivers. It is separated from the Mt. Humboldt mass by the valley of the Russell Falls River, which is in turn separated from the central plateau by the valley of the Florentine and Derwent.



The topography is simple, being the eastern and almost square end of the range, rising fairly evenly with increasing gradient, the final 400 ft. at an angle of 30 degrees. In one part the edge of the sill capping the plateau has broken away to form cliffs ('Organ Pipes') about 300 ft. high of the columnar dolerite. The top of the range is almost flat, sloping gradually to the west, with a consistent slope of 9 deg., and falling 200 ft. in about half a mile. There is then a sudden drop of about 30 ft. to a flat swampy plain of glacial origin, at the head of the North-west Bay River. On the western side of these swamps, a steep North-South dolerite ridge (Mt. Arthur) rises to 4100 ft. The northern and eastern sides of the range are drained by small creeks, while the whole of the top drains into the swamps and thence to the N.W. Bay River. This flows south, descending rapidly in a series of cascades, then turning south-east at approx. 1500 ft. through the foothills to the D'Entrecasteaux Channel.

**Geology.**—For the most part, the plateau is capped by a Jurassic (?) dolerite sill about 1600 ft. thick, overlying Triassic sandstones of about 800 ft. depth, resting on an Upper Permian base.

In many places the edges of the dolerite sill have broken away and descended as extensive talus slopes, which have covered over the sandstone, except in isolated places on the shoulders of spurs and in some cases have descended further and covered over mudstones as far down as the 700 ft. contour. Smaller dolerite masses at lower levels are found in the foothills, notably at Neika, Chimney Pot Hill and Mt. Nelson. These are sometimes lower sills intrusive into Permian strata and sometimes the results of block faulting of the main plateau mass.

These talus slopes have an important effect on the vegetation, providing a well drained rocky soil with no surface water. Drainage from above flows through and under this talus to appear when the mudstone and sandstone protrude from beneath. This type of physiography, summit cap of dolerite with talus covering sandstones and mudstones, is characteristic of most of the mountains in the eastern two-thirds of Tasmania and is thus an important ecological feature. The initial stages of a xerosere has formed on this talus slope, which has been colonized except for unstabilized patches (locally called 'Ploughed Fields or Potato Fields'). Serious bush fires and consequent erosion on the south slopes have removed plant and soil covering, and parts have reverted to the open talus which, is being recolonized slowly.

The summit of the plateau shows evidences of glaciation, the area 'Dead Island' being an example of a 'nunatak'.

**Soils.**—The soils of Mt. Wellington fall into two broad groups, the High Moor and Skeletal soils of the plateau and upper slopes and the podsols below the 2500 ft. contour. In flat to gently sloping sites where they are fully developed, the high moor soils consist of between two to three feet of fine black peat with some coarser organic remains in the top few inches, overlying a stony and clayey horizon of deposition and weathering. There is rarely any evidence of a well-marked horizon of deposition alone. In localities which vary from relatively gentle slopes to cliffs and where the natural erosion process is faster than the weathering process, extensive areas of exposed rock in boulders and sheet rock occur. Frequently some soil and organic material is lodged in cracks and crevices in this rocky terrain. Where the erosion and weathering process are in the balance, areas of skeletal soils occur. These consist of shallow stony, clayey soils with little or no accumulation of organic matter and frequently containing large boulders.

The podsols of the lower slopes consist of dark grey and sandy loams with much organic matter above a more or less distinct bleached horizon, which in turn overlies

yellow and grey clays. In areas of somewhat restricted drainage there is a greater accumulation of organic matter, with the result that the soil approaches a peaty sand and directly overlies the clay subsoil.

On the flat tops of the sandstone layers not covered by the talus, acid swamps have developed in some parts consisting of black peaty sand over yellow clay. These are shallow and subject to drying out, and so do not support the Button Grass (*Gymnoschoenus aemulus* Nees.) swamp characteristic of the permanently wet type of acid swamp in the west and south.

**Climate.** (Information supplied by the Divisional Meteorologist, Hobart.)

**Rainfall.**—The mean annual rainfall varies from 23.97 inches to nearly 60 inches on Mt. Wellington. (See Table I).

TABLE I

Place	All. Ft	J	F	M	A	M	J	J	A	S.	O	N.	D	Mean
Hobart ..	177	1.84	1.49	1.73	1.97	1.85	2.21	2.13	1.83	2.07	2.33	2.43	2.09	23.97
Waterworks	527	2.62	2.01	2.75	3.14	2.47	2.98	2.90	2.30	2.89	3.67	2.65	3.15	33.53
Ferntree ..	1300	4.44	3.62	4.20	4.90	3.94	4.64	4.59	4.17	4.55	5.86	4.74	5.51	55.16
Springs ..	2403	4.48	3.35	4.76	5.47	4.43	5.21	4.74	4.22	4.89	5.72	2.77	5.51	57.58
Gap ..	4000	4.04	3.36	4.53	5.43	4.04	4.62	4.18	3.52	4.83	6.04	4.95	5.81	55.35

With distance from the mountain, the rainfall decreases rapidly almost independently of altitude, but on the mountain the 1200 contour corresponds approximately with the 50" isohyet. The seasonal variation in monthly rainfall is not pronounced. At Hobart a mean minimum of 1.49 points occurs in February, monthly averages gradually increase to 2.43 points in November, but a slightly secondary minimum is shown in August. There is, however, a marked fluctuation at irregular intervals, the lowest total in one month ranging from 0.03 (January) to 0.39 (September) and the highest total 5.91 (January) to 10.16 (August). Droughts occur. Southern Ocean depressions are responsible for 50 per cent of the rainfall. The rain is gentle; on 70 per cent of the days of rain the amounts are less than 15 points. Heavy falls of over an inch in 24 hours are of comparatively rare occurrence. Local variation is considerable.

In addition to the rain, the mountain above 1300 ft. is often mist-covered as the result of easterly weather, and in the summer the afternoon sea breeze often produces a bank of cloud on the South-east face. In conjunction with other factors this has an important effect on the vegetation.

**Temperature.**—The average monthly maximum and minimum temperatures for Hobart and the Springs are given in Table II (below).

TABLE II

	J.	F.	M.	A.	M.	J.	J.	A	S	O.	N	D	Mean
Hobart ..	71.0 52.8	71.1 53.4	67.9 50.9	62.5 47.7	57.4 43.9	52.7 41.0	52.1 39.6	55.1 41.1	58.8 43.3	62.6 45.6	65.8 48.3	79.0 51.2	62.2 46.6
Springs ..	60.0 44.1	61.7 45.7	57.8 43.7	52.4 40.6	48.4 38.2	44.8 35.9	43.9 34.9	45.3 35.3	49.0 36.4	52.2 38.0	55.6 40.0	58.1 42.7	52.4 39.6

In Hobart the absolute highest temperature was 105.2° F. and absolute lowest 27.7° F.

Table III gives the average hours of sunshine per month for Hobart.

TABLE III

J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.	Total
233.9	194.2	198.2	142.7	142.1	118.2	128.5	159.1	173.1	191.3	220.0	217.0	2118.3

The mean amount of cloud per month (on a scale 0-10) is very even, ranging from 5.8-6.4. The mean monthly humidity for Hobart ranges from 58-80 per cent and for the Springs 70-77. There is considerable wind action in Hobart. Gusts of over 60 m.p.h. may be experienced in any month, and the mean total miles in 24 hours ranges from 150-160 per month. This must be more severe at higher levels, especially on the plateau.

Snow may fall on the mountain in any month, but rarely lies more than a few days at altitudes below 2400 ft. Table IV gives average number of days of snow fall.

TABLE IV

J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.	Total
0.3	0.2	1.0	1.8	2.7	3.9	4.0	4.6	3.2	2.4	1.7	0.5	26.3

Above 3000 ft. it may lie for weeks at a time during the months from May to September, and at 4000 ft. large areas may be covered continuously during that time and isolated drifts may last into November. Frosts occur down to sea level in open areas in winter months, but forest cover prevents their formation below 1500 ft.

*Exposure.*—The top and west sides of the summit of Mt. Wellington and the Mt. Arthur ridge and the N.W. sides of the range and its foothills receive maximum sunlight and experience maximum evaporation. The summit ridges experience also lowest temperature and maximum wind. The steep eastern face loses direct sunlight before mid-day in winter, while the shadow of the mountain covers most of the S.E. slopes early in the afternoon. The south face receives little direct sunlight except in summer.

#### STRUCTURE OF THE PLANT FORMATIONS

Two main formations exist in this area, one including a very reduced third type:

1. *Eucalyptus forest formation.*—This covers the greater part of the area, and varies from open forest of the lower slopes and foothills to dense *E. regnans* forests. Within this formation several sheltered gullies support a 'gully flora' of a subantarctic rain forest type called 'mixed forest of the West Coast' by Gibbs (1920), analogous to the 'gully flora' of tropical rain forest origin occurring in the Eucalyptus formation on the Hawkesbury sandstones (Pidgeon, 1938).
2. *Austral-Montane Formation* (Gibbs, 1920).—This occupies an area of very limited extent on the summit of the range, and is restricted both in area and composition by the relative dryness and warmth of the situation compared with that on mountains further inland where a fuller development obtains. Shrubberies of alpine conifers, dwarf *Arthrotaxis* forests, *Nothofagus* shrubberies and plant mosaics are absent.

The sides of the plateau, except the top of the steep eastern face, are occupied by *Eucalyptus* forest formation. On the summit all places with sufficient depth of soil and drainage and which are not exposed to the full force of the wind, also support stunted *Eucalyptus coccifera* forest. Elsewhere on the summit the fairly well-drained but shallow soils support the reduced Austral-Montane formation, while the poorly drained area is occupied by swamps analagous to those of Barrington Tops (Fraser and Vickery, 1937-39) and Kosciusko (McLuckie and Petrie, 1927). Exposed rock surface occurs in many places, mainly unstabilized dolerite talus. The initial stages of a xerosere are to be found here, as the slopes are being colonized slowly by the shrubs from the *E. coccifera* and *E. coccifera-urnigera* associations.

#### THE EUCALYPTUS FORESTS

##### (1) *E. coccifera* Consociation

These species form a pure consociation between 3600 and 4000 ft. It occupies the rocky soils and stabilized boulder masses, and is limited in its distribution by three main factors:

(a) *Drainage and water supply*, which restricts the distribution of the consociation to the steeper and rockier parts, where there is adequate drainage and aeration, but which receive a good supply of water from higher levels. The effects of this factor are everywhere apparent. All slopes of approx. 10-30 degrees with a reasonable supply carry the consociation. The lesser slopes and very shallow soils support the grassland and shrub communities, and the poorly drained areas the swamps. The relation to drainage and water supply is strikingly demonstrated by 'Dead Island'. This is a 'nunatak' within the swamps and rising a few feet above the water table, thus providing sufficient aeration and permanent water for the consociation to develop as an 'island' of eucalypt within the swamp.

Within the consociation where drainage fails or the water supply is inadequate, it is sharply replaced by patches of swamp associes such as mats of *Astelia*, *Gleichenia dicarpa*-*Baeckia Gunniata* mixtures or by grassland and shrub communities. The relationship between forest and swamp is comparable to that described for *E. pauciflora* on Barrington Tops and Kosciusko.

(b) *Exposure*.—Though low temperature may have some effect on the distribution of *E. coccifera*, it seems more probable that the higher transpiration coupled with a rapidly draining and drying soil prevent its establishment on the top of the plateau and high up on the ridges. Exposure reduces the size of the species from trees 15 ft. high and 18 in. thick to prostrate shrubs a few inches high with permanently juvenile foliage at practically the same altitude.

(c) *Competition*.—On the side of the plateau the lower limit of the species is determined by competition, mainly with *E. urnigera*, which begins to appear at 3600 ft. Below this level to 3000 ft. the balance is a delicate one and determined by local climatic variation and power of regeneration from fire. *E. coccifera* is more drought and cold resistant than *E. urnigera*. It is unhurt by long periods under snow or even colder conditions, when the foliage is covered with thick masses of ice for a period of days. (An exceptionally long period of icing about 15 years ago killed off large areas of the *E. coccifera* consociation, however.) Though *E. urnigera* is less frost and drought resistant, it regenerates better and grows faster, so that mild winters and fires favour its spread at the expense of the other species. Dense stands of *E. urnigera* saplings occur in many places in the more sheltered and lower parts of the *E. coccifera-urnigera* association, with logs and occasionally large living trees of *E. coccifera* within them, indicating an active extension of the *E. urnigera* component.

The *E. coccifera* consociation (assisted by the rocky nature of the ground) is fairly open in most places, permitting the development of an important shrub stratum. This comprises members of the reduced Austral-Montane association adjoining with the exception of extreme heliophilous and swamp types. In the more sheltered and wetter portions it includes shade and moisture loving species from the lower associations such as *Bauera rubiodes*, *Nothogagus Cunninghami* (shrub form) and *Leptospermum lanigerum*.

The *E. coccifera* consociation is of common occurrence on Tasmanian mountains in the eastern half of the island. It forms with *E. vernicosa* the advance margin of the Eucalypt into the remnants of the Austral-Montane, which survives where cold, exposure, shallow soils and long periods under snow halt the more vigorous tree invader.

## (2) *E. coccifera-urnigera* Association

Below 3600 ft. on the outer slopes of the plateau, *E. urnigera* is associated with other Eucalypt species. It does not form pure stands except as consociates of saplings (see above). At the upper limit of its distribution it becomes less frequent until pure *E. coccifera* is found, and on the lower limit it cannot compete with *E. gigantea* and *E. regnans*.

It is confined to stabilized dolerite talus in those parts where good drainage, continuous water supply and shelter from drying winds obtain. Where drainage is poor and conditions are swampy, the species is dwarfed to a shrub and may never develop adult foliage. It is also very scanty on steep slopes where the soils drain out quickly or where the trees are exposed to insolation and drying winds. In such places *E. coccifera* continues in a nearly pure state down to the *E. gigantea* community.

The shrub layer presents a rich and varied facies as a result of the warmer conditions, shelter, the plentiful supply of water draining from above combined with the effects of the open canopy. The more heliophilous types of the summit plateau cannot compete, and are replaced by more mesomorphic species, e.g., *Orites acicularis* and *O. revoluta* are replaced by *O. diversifolia* and *Richea Gunnii* and *R. scorparia* by *R. dracophylla*. *Bauera rubiodes*, *Leptospermum lanigerum* and *Telopea truncata* reach their maximum development in the wetter parts. On the other hand shrubs such as *Gaultheria hispida*, *Cyathodes glauca*, *Prostanthera lasianthos*, *Gahnia psittacorum*, *Hakea macrocarpa*, *Olearia viscosa*, *Correa* spp, *Bedfordia salicina* and *Pleopeltis diversifolia* (Fillices) are at the upper limit of their distribution. The shrub layer is the most varied of any of the associations, containing many elements from the *E. coccifera* and summit plateau associations from above and the *E. obliqua-regnans* association from below. *E. Johnstoni* is common towards the lower levels of the association.

An interesting feature of this association at lower levels is the colonization of sheltered patches of open talus by the fern *Pleopeltis diversifolia*, whose tough rhizomes twine among the boulders and help the accumulation of soil and humus.

At levels below about 2500 ft. *E. urnigera* cannot compete with *E. gigantea* and *E. regnans* and is quickly displaced.

## (3) *E. obliqua-regnans* Association (800 ft.-2500 feet)

This association is not a very intimate one and varies within wide limits in its composition according to differences in local climate. On the upper limit, *E. gigantea* may largely or completely replace *E. obliqua*, and one might be justified in defining an association on Mt. Wellington with the former as the important element representing the extensive *E. gigantea* associations found in other parts

of the island. However, until these have been studied and defined, these *E. gigantea* communities have been included as an element of the *E. obliqua-regnans*.

At its lower level, *E. obliqua* passes into the open forests of the drought resistant species (*E. obliqua*, *E. tasmanica*, *E. viminalis*, *E. salicifolia*, *E. linearis*) characteristic of the foothills below 1000 ft.

According to aspect, moisture supply and exposure, either *E. obliqua* or *E. regnans* may become locally dominant or form pure stands. Where specialized conditions prevail specialized communities have developed (gully communities, sandstone communities). *E. urnigera*, *E. Johnstoni* and *E. globulus* also occur.

This association is the most important type of commercial forest in S.E. Tasmania. For this reason and also because of bush fires it exists in greatly reduced form in the area studied.

Dealing with the two most important species separately:—

#### *E. obliqua*

This species has wider distribution in the association, and is found in all parts of the forest, and often forms pure societies on the drier places, such as the tops and western sides of the ridges. It becomes attenuate towards the wetter parts, where it is replaced by *E. regnans* and by *E. gigantea* at high altitudes. It occurs into the open forest association as an important element.

Where this species is dominant the canopy is fairly open, and an important tall shrub layer of a relatively xerophytic type develops with *Acacia verniciflua*, *Eriostemon squameus*, *Ozothamnus rosmarinifolius*, *Pultenea juniperina*, *P. daphnoides*, *Monotoca lineata* and *Oxylobium ellipticum* as important characteristics. Frequent fires and consequent denudation have greatly reduced the tall shrub layer in many parts, but there is no doubt that it was an important element in the climax community, and replacement of the older trees was dependent on quick germination and growth in temporary clearings.

#### *E. regnans*

From the drier tops and exposed N.W. sides of the ridges towards the shadier S.E. sides, *E. obliqua* is replaced by *E. regnans*. Here the tall shrub layer is also well developed, but presents a more mesomorphic appearance. *Olearia argophylla*, *Pomaderris apetala*, *Bedfordia salicina*, *Acacia dealbata*, *Zieria Smithii*, *Prostanthera lasiantha*, *Gahnia psittacorum*, *Pittosporum bicolor*, etc., displace the types dominant with *E. obliqua*. There is no low shrub or herb layer (except ferns) in the denser parts, but occasional more open parts support shrubs such as *Gaultheria hispidula*, *Drimys lanceolata*, *Correa Lawrenceana*, *Olearia myrsinoides*, *O. stellulata*, *Aristotelia peduncularis*. Ferns such as *Polystichum aculeatum*, *Blechnum capense*, *Histopteris incisa*, *Pleopeltis diversifolia*, etc., occur.

In the wettest parts *Olearia argophylla* dominates the shrub layer and has a canopy of leaves about 15 ft. above the ground, supported by a mass of bare stems about 3 inches thick. Only such ferns as *Dicksonia antarctica*, *Polystichum aculeatum*, *Blechnum* sp. and *Pleopeltis diversifolia* develop on the floor, and the structure approaches that of the lower parts of the 'gully flora', but with occasional *E. regnans* trees.

On the South-east side of the mountain *E. regnans* reached its maximum development, formerly having formed large societies of magnificent trees up to 200 ft. high. These were destroyed by fire in 1914, and subsequent erosion hindered regeneration in many parts. In others it is proceeding actively, and there are large areas of regrowth with the white skeletons of the previous forest rising above them. In these areas the canopy is denser and the shrub layer of less importance than in other parts of the association, but still well represented.

Replacement of the trees in the mature forest takes place in clearings made by falling trees or by fires. The Eucalypt seedlings cannot establish themselves beneath an undisturbed tall shrub layer. The bottoms of the gullies being always moist are never affected by fires, and the Eucalypt can never become established, and a 'gully flora' exists (see below).

Towards the lower levels, *E. regnans* is replaced by the *E. globulus* communities, which occupy the sheltered parts of the open forest association.

The following specialized communities occur in the association:—

(a) 'Gully Flora'

At the bottom of those gullies not exposed to the dry north-westerly winds, *E. regnans* cannot establish itself in the dense shrub layer, and a 'gully flora' exists.

At altitudes up to approx. 1500 ft. the dominants are *Olearia argophylla*, *Pomaderris apetala* and *Bedfordia salicina*, which form a canopy of leaves 15-20 ft. above the ground, supported by a thicket of bare stems approx. 3 inches in diameter, with occasional thicker ones of *Atherosperma moschata* and *Acacia dealbata*. The shaded ground can support no shrubs, and generally only ferns, stunted *Dicksonia antarctica*, *Polystichum aculeatum* and *Blechnum* spp. grow on the floor, while *Pleopeltis diversifolia* scrambles over fallen logs and thicker tree stems, and mosses and liverworts may occur on the thinner ones. The area close to the creek at the bottom of the gully is occupied by fern communities dominated by *Dicksonia antarctica* (up to 20 ft. high) and a rich fern, moss and liverwort ground flora. Light breaks, such as may be caused by neighbouring eucalypt trees falling into the gully, may be colonized by *Acacia dealbata*, and mature societies of this species, consisting of trees 9 in. thick, may be seen rising 10-20 ft. above the surrounding vegetation.

At higher altitudes the *Olearia* and *Pomaderris* are replaced by communities of *Nothofagus-Atherosperma* forest, which may be regarded as small areas of reduced microthermal rain forest (Herbert, 1935), existing where local conditions are suitable. They are related to the more extensive forests occurring at the upper reaches of the river valleys in the S.E. of Tasmania (Kermadec, Esperance, etc.), where a similar transition from *E. regnans* forests to *Nothofagus-Atherosperma* forests occurs on a larger scale.

In the gullies on Mt. Wellington the *Nothofagus* trees reach about 40 ft. in height, and the *Atherosperma* 20-30 ft., with occasional trees of *Acacia melanoxylon* and *Olearia argophylla*, *Bedfordia salicina* and *Pomaderris apetala* in the drier parts. Cold and lack of shelter limit the distribution of most of the 'gully' species to below approx. 2300 ft., with the exception of *Nothofagus* which protrudes into the Eucalypt forest at the heads of some of the gullies and reappears as the shrub form at higher altitudes in the *E. urnigera* and *E. coccifera* associations.

Light breaks in the upper 'gully' vegetation are colonized by *Nothofagus* seedlings and not by Eucalyptus from the surrounding forests, confirming observations on the vigour of this species under suitable moisture conditions made by Herbert (1936) and Fraser and Vickery (1937-39). The frequent periods of low humidity prevent its spread beyond the gullies, except as an occasional small tree in the *E. obliqua-regnans* or as the shrub form at higher altitudes.

(b) Sandstone communities

The triassic sandstones are exposed on the shoulders of the ridges, which protrude far enough from the main mass of the mountain to have been covered by the dolerite talus from above (2000-2400 ft.). In this acid sandy soil, which in

some places is poorly drained and swampy, communities are found which are different to the *E. obliqua-regnans* forests on the mudstone below and the *E. urnigera-coccifera* on the dolerite talus above.

The most striking feature is the dominance of *E. Johnstoni* which is of minor importance elsewhere, and the almost complete absence of *E. urnigera*. *E. Johnstoni* is of special systematic interest (Brett, 1938), and is confined to Mt. Wellington and a few other places in S.E. Tasmania where it is not common. It appears to some extent in the *E. urnigera-coccifera* association above, where it occupies a position similar to that of *E. suberenulata* in similar associations in other parts of the island. It is very rare in the *E. obliqua-regnans* forest below.

At the Springs and White Rock, which are fairly well drained, the species attains the height of approx. 30 ft. Shrubs from the drier parts of the *E. obliqua* forest, such as *Monotoca lineata*, *Oxylobium ellipticum*, *Eriostemon squameus*, *Pultenea juniperina*, occur. In the more open parts, plants characteristic of sandy heaths, *Leptospermum scoparium*, *Epacris impressa*, *Richea sprengeliodes*, *Banksia marginata*, etc., appear, and in the wetter parts *Gaultheria hispida*, *Bauera rubiodes* and *Richea dracophylla*.

At Snake Plains, which is badly drained, the facies is different again. On the north and west of the area the talus from the mountain above has rolled down onto the sandstone, while on the south it is buttressed by a small dolerite mass, and on the east it falls away in cliffs. The top of this sandstone platform is very flat except for small rocky outcrops a few feet high which support dwarf *E. Johnstoni* and the plants of the drier phase. The soil is shallow, and consists of practically pure black peat, supporting mainly a herbaceous vegetation of plants characteristic of acid sandy peaty soils, dwarfed *Gahnia psittacorum*, *Sprengelia incarnata*, *Restio australis*, *Hypolaena lateritola*, *Richea sprengeliodes* and dwarf *Melaleuca squamea*, etc. Where the soil is slightly deeper and better drained, dense thickets of myrtaceous shrubs, 6 ft. high (*Leptospermum scoparium* and *Melaleuca squamea*), exist with the hardier plants of the drier phases such as *Monotoca lineata* and *Oxylobium ellipticum*. The small prostrate *Coprosma Moorei* is common on the bare peat. On the talus slope immediately above, the forest is regenerating following the fires of 1914, and dense stands of small trees of *E. Johnstoni* and *E. urnigera*, with an impenetrable mass of *Gahnia psittacorum* and *Bauera rubiodes*, spring from among the fallen logs of the old forest.

On the south side, the ecotone between the swampy plains on the top of the sandstone and the *E. obliqua-regnans* on the well-drained dolerite is very sharp.

#### (4) The Open Forests of the Lower Slopes and *E. globulus* Communities

These are outside the area studied, but a brief description is given to complete the picture.

The foothills consist of either mudstone or dolerite ridges. In the case of the first, the soil is shallow and impervious and the water quickly shed, and in the second the soil is subject to drying and cracking. Added to this the rainfall is low (25-30 in.). On the tops and north and west sides of these ridges, there is a stunted open forest of *E. linearis*, *E. salicifolia*, *E. viminalis*, *E. tasmanica*, with occasional *E. obliqua* and *E. globulus* where water conditions are better. The tall shrub layer is scanty or absent, but grasses and *Cyperaceae* and hardy low shrubs such as *Acacia stricta*, *A. vomeriformis*, *A. verticillata*, hardy *Epacridaceae* *Leguminosae* and *Rutaceae* occur.

On dolerite ridges, *E. linearis* often assumes dominance, and may form societies (Chimney-pot Hill), but generally the elements are mixed. In some cases the mudstone ridges have been so denuded of soil that only a stony clay remains,



supporting societies of *E. Risdoni* and its hybrid complex (Brett, 1938). The soil is too poor to support grass sward, and hardy small shrubs of *Epacridaceae* and *Leguminosae* fail to cover soil.

On the south and east sides of the ridges, the shade, shelter from the dry north-westerly winds and perhaps the effects of the moist sea breeze and the assistance given to the retention of water by the dip of the mudstone rock, form a marked local climatic contrast to the tops and west sides and have permitted the development of *E. obliqua-globulus* communities. These were formerly of great importance, but the value of the *E. globulus* and *obliqua* timbers led to their exploitation in the early days of the settlement. They now exist in reduced form only towards the heads of the gullies and isolated patches. Towards the top of the ridges, *E. obliqua* and *E. viminalis* predominate, but towards the bottom of the valleys *E. globulus* becomes increasingly important until it forms an almost pure society.

#### AUSTRAL-MONTANE FORMATION

This formation is very reduced and impure on Mt. Wellington, lacking many of the elements characteristic of other summit plateaux, where rainfall is more reliable and generally moister and colder conditions prevail. The conifers, *Arthrotaxis* spp., *Microcachrys tetragona*, *Phaerosphaera Hookeriana*, *Diselma Archeri* are absent, the only one present being *Podocarpus alpina*, and that does not form shrubberies. There are no dwarf mountain forest or herbaceous associations (Gibbs, 1920), with the exception of *Astelia alpina* communities. However, all the more xerophytic shrubs usually found in this formation are present, so the classification is retained. Three types of community are found:

##### (1) The Shrubberies

These occupy all the flat top of the mountain, except where the *E. coccifera* consociation and the swamp and grassland are found and the upper portion of the steep eastern face. It exists on the top by virtue of its capacity to endure wind and dry conditions too severe for *E. coccifera* and where there is too little soil and too many rocks for the *Poa caespitosa* grassland to compete.

On the upper portion of the steep eastern face, drainage and water supply are sufficient to support the *E. coccifera* consociation, but snow is blown off the flat top into deep drifts on this area and prevents its establishment. The low rounded shrubs of the formation can tolerate these conditions better than the *Eucalyptus* trees.

The vegetation takes the form of (a) rounded bushes 1-3 ft. high, such as *Orites acicularis*, *O. revoluta*, *Richea Gunnii*, *Richea scoparia*; (b) more upright bushes, 1-2 ft. high such as *Ozothamnus ledifolius*, *Olearia ledifolia*, *O. pinifolia*, *O. persoonoides*, *Coprosma nitida*, *Drimys lanceolata*, etc.; (c) prostrate or creeping over boulders, e.g., *Leptospermum rupestre*, *Bauera rubiodes*, *Exocarpus humifusa*, *Pentachondra pumila*, *Monotoca empetrifolia*, *Cyathodes dealbata*; (d) sub-erect mats to 1 ft. high, e.g., *Baeckea Gunniana*, *Cyathodes straminea*, *C. adscendens*, *Richea acerosa*, *R. sprengeloides*; and (e) herbs, e.g., *Astelia alpina*, *Poa caespitosa*, *Gleichenia dicarpa*, *Hypolaena laterifolia*, *Lycopodium* spp. and annuals. Only one 'bolster' plant (Sutton, 1929), *Abrotanella Fosterioides*, exists. Many of these shrubs occur in the *E. coccifera* consociation. Where the weathered rock has accumulated sufficiently to provide stretches of soil, the shrubberies are replaced by *Poa caespitosa* grassland, with scattered shrubs principally *Ozothamnus ledifolius* with *O. Hookeri*, *Orites acicularis* and *Richea Gunnii* less common.

## (2) The Swamps at the Head of the North-west Bay River

Between the Mt. Wellington plateau and the Mt. Arthur ridge, there lies a shallow valley of glacial origin (3650-3800 ft.) about half a mile square. This receives all the drainage from the top of the mountain and a peaty swamp has developed. This is drained by the North-west Bay River which descends rapidly in cascades into the gorge between the Mt. Wellington mass and Mt. Montagu and the Thumbs. The river is very slowly cutting back into the swamp and a border of grassland at the farther edge indicates a succession.

Succession is so very slow that the area has probably remained unchanged over a long period, and the swamp may be regarded as relatively permanent. Succession of dry years have at times reduced the swamp and increased area of the grassland, shrubs and *E. coccifera*, which have been reduced again by the increase of the swamp in wet years.

One method by which the swamp and grassland developed can be observed on the higher areas in the small slowly moving streams flowing over the rock. A succession involving the 'bolster' plant *Abrotanella Fosterioides* can be traced. These plants colonize the edges and shallow waters, and by apical growth throw themselves into spreading mounds, which slow up and dam the flow. When about 3 ft. in diameter, the colony begins to die at the centre forming a bed for the establishment of *Hypolaena laterifolia*, *Baeckia Gunniana*, *Astelina alpina*, *Gleichenia dicarpa* and annuals, and if the drainage continues to be restricted the swamp associates develops. If, however, the stream breaks through and drains away in another direction, the succession tends towards the grass and shrub vegetation. In some places the periphery of mounds once up to 9 ft. in diameter can be traced in the swamp grassland ecotone.

The main part of the swamp consists of a dense mat of vegetation capable of supporting one's weight, the living portion being about 6 inches thick and deriving its firmness mainly from the stiff leaves of *Astelina alpina*. There is considerable local variation in composition, and, though the different successions have not been studied, they are probably as complex as those described for Kosciusko by McLuckie and Petrie (1927). The basis appears to be a mixture of *Astelina alpina*, *Gleichenia dicarpa* and *Restio australis*, with *Baeckia Gunniana* and *Hypolaena laterifolia* in the slightly drier parts. In places *Astelina alpina* may exist in a practically pure state, while in other intimate mixtures of *Astelina-Gleichenia*, *Baeckia-Gleichenia*, *Gleichenia-Hypolaena*, etc., exist. Quite frequently, *Richea scoparia*, *R. Gunnii*, *O. acicularis*, *Ozothamnus Hookeri* have managed to obtain a foothold, the large yellow bushes of *Orites acicularis* being particularly conspicuous.

*Sphagnum* occurs floating in the pools and as old mounds in the main body of the swamp, which are colonized by shrubs (chiefly *Richea scoparia*), and persist to a relatively late stage in the succession. It does not appear, however, that *Sphagnum* played an important part in the succession, and thus the swamps here are closer to those of Kosciusko than of Barrington Tops.

## (3) Grassland

As the result of entrenchment and drainage of the upper levels in the past, there is a succession to grassland. *Restio australis* is the first to disappear. *Astelina* and *Gleichenia* become less important, and *Hypolaena laterifolia*, *Cyperus alpina* and *Baeckia Gunniana* become more important, and annual compositae, *Euphrasia collina*, *Gentiana dimensis*, etc., and shrubs appear. *Poa caespitosa* and the shrubs of the grassland *Ozothamnus* spp. and *Olearia* spp., *Monotoca empetrifolia*, *Epacris serpillifolia*, etc., increase in importance.

It is probable also that the grassland forms a subclimax on the top of the Mt Wellington plateau, where the soils are too shallow and windswept to support *E. coccifera* and, as erosion is barely balanced by weathering, cannot become deeper. In other places, however, where the soil can accumulate from the weathering of higher elevations, such as the foot of the Mt. Arthur ridge, the *E. coccifera* is invading the grassland slowly.

#### CONCLUSIONS

##### The Eucalypt Forest Types

These range from dwarfed and fairly open *E. coccifera* forest on the summit to the dense *E. regnans* of the lower slopes. The species show definite vertical sequence. *E. coccifera* exists as a pure consociation down to about 3600 ft. below which the *E. urnigera* appears in increasing amounts to 2500 ft., where it is succeeded by *E. gigantea* and *E. obliqua-regnans*, which is replaced by the open forests and *E. globulus* communities of the lower slopes.

Four main types have been recognized:

##### (1) *E. coccifera* Consociation

This natural consociation is believed to be widespread in Tasmania, and represents the upper limit of the invasion of the Eucalyptus formation into the Austral-Montane formation. In comparing it with *E. nipophila*<sup>(1)</sup> consociation 1000 ft. higher at Kosciusko, it is apparent that the shrub layer on Mt. Wellington is of greater richness and importance, and from a Tasmanian viewpoint the facies at Kosciusko is relatively 'warmer' and mesomorphic. The shrubs in common are *Drymys lanceolata*, *Helichrysum baccharides* (*Ozothamnus Hookeri*) *Oxylobium ellipticum*, *Podocarpus alpina*, *Richea Gunnii* and *Lissanthe montana*, and of these only *Helichrysum baccharoides*, *Podocarpus alpina*, *Lissanthe montana* and *Richea Gunnii* are generally confined to the *E. coccifera* consociation; the others reach their greatest importance at lower levels. Many of the commonest shrubs in the Kosciusko consociation, e.g., *Veronica derwentia*, *Helichrysum rosmarinifolium*, *Olearia myrsinoides*, *Prostanthera cuneata*, *Cassinia aculeata* occur in Tasmania at very much lower levels only, and the genera of most of the others are represented by low altitude species. The herb species show a similar distribution.

As it is probable that the climate of Kosciusko is much colder than at Mt. Wellington, the 'warmness' of the shrub facies at the former presents an interesting problem. It may be noted that it is the xeromorphic Kosciusko species which are represented in the *E. coccifera* consociation, while the mesomorphic *Veronica derwentia*, *Helichrysum rosmarinifolium*, *Cassinia aculeata* are restricted to lower levels which suggests that the difference may be due to the water factor. Unless we assume the existence of strains of different cold resistance in the two places, their absence in *E. coccifera* cannot be due to the temperature but to water availability. The extremely rocky nature of the terrain, the scanty or shallow soil with poor water-retaining capacity, droughts and high winds prevents the establishment of the water-loving species.

It seems not impossible that the endemism of many of the montane species of Epacridaceae and Proteaceae, etc., in Tasmania may be due in part to the advantage their xeromorphic habit gives them over the more mesomorphic forms which dominate the shrub layer at Kosciusko and which can exist in Tasmania only at lower levels.

The *E. Gunnii* consociation described for Kosciusko by McLuckie and Petrie (1927) does not occur on Mt. Wellington. The species referred to there is not

(<sup>1</sup>) = *E. pauciflora* = *E. coriacea* of McLuckie and Petrie (1927).

the *E. Gunnii* of Tasmania, but is probably *E. glaucescens* (Blakely, 1934). In Tasmania *E. Gunnii* Hook. forms societies at 2500 ft. to 3500 ft. on the Central Plateau, where it prefers marshy conditions and bears little ecological resemblance to the Kosciusko association.

The *E. pauciflora* association of Barrington Tops (Fraser & Vickery, 1937-9) is also not present on the area studied. This species occurs in Tasmania in the 'Midlands' and Central Plateau as extensive open forest. The two associations may be ecologically related, but the local one is yet to be studied. The definite identity of the species in the two places is yet to be confirmed (Brett, 1938).

## (2) *The E. coccifera-urnigera* Association

This association is formed by the entry of *E. urnigera* into the *E. coccifera* forest at below 3600 ft. It competes successfully with the slower-growing species under favourable conditions, and on Mt. Wellington has invaded and displaced it over considerable areas. It is, however, less cold, wind and drought resistant, and upward extension is limited by these factors. Extension to lower levels is limited by the competition of the vigorous *E. gigantea* and *E. obliqua-regnans*.

On Mt. Wellington *E. Johnstoni* occurs in the *E. urnigera* association. This species, however, does not assume the importance that its close relative *E. subcrenulata* does on other mountains. A widely-occurring *E. coccifera-subcrenulata-urnigera* association may eventually be defined of which the Mt. Wellington association with *E. Johnstoni*, vice *E. subcrenulata*, will form a part.

The relation of *E. urnigera* to the dolerite talus slope has been described above (p. 102). Little soil exists in this region, and the water quickly percolates through; consequently the shrub layer is still predominantly xeromorphic. The less heliophilous species from the *E. coccifera* consociation above and the more drought-resistant species from the *E. obliqua-regnans* below mingle.

It seems probable that *E. urnigera*, which has perhaps been evolved in Tasmania, has proved specially suited to resist competition on this specialized habitat to which it is still largely confined. Following fires, it competes successfully with *E. coccifera*, but a series of very severe winters will probably reverse this tendency. At lower levels it cannot compete successfully with *E. regnans* and *E. gigantea*, though it persists in these associations as a minor element down to 2000 ft. It is not found off the talus soils, though it can be cultivated on any moist well drained soil type. In swampy places in its own association or even in the upper parts of the *E. obliqua-regnans* association, *E. urnigera* exists as a shrub, often not losing its juvenile foliage. It is a species of great ecological interest, confined to Tasmania, but with affinities there only with *E. divaricata* (see Brett, 1938).

## (3) *E. obliqua-regnans* Association

This rather loose association comprises the chief commercial forests in S.E. Tasmania. The composition varies markedly with changes in local climate, *E. obliqua* predominating in the drier parts and *E. regnans* in the more sheltered. Its upper limits are defined by temperature and by soil type and the lower by rainfall. It is thus characteristic of mudstone soils with a rainfall of over 35 in. per annum.

At its upper limits in the drier parts the *E. obliqua* is replaced by *E. gigantea*. On the lower limits, where the rainfall is below 40 in., the *E. obliqua* element of the more exposed parts is replaced by the open forest association and the *E. regnans* element of the more sheltered regions by the *E. globulus-obliqua* communities.

A general comparison of this association with portion of the Eucalypt forest of Barrington Tops (see Fraser & Vickery, 1937-9) is possible. There the crests

and upper slopes of the ridges 2800-3500 ft. are occupied by *E. obliqua* forest. This gives place to *E. viminalis*, which is in turn replaced by *E. fastigata* at 4200 ft. (*E. fastigata* is closely related to *E. regnans* (see Blakely, 1934)). The higher rainfall at Barrington is probably offset by the greater seasonal variation and higher average temperature, which would also tend to equalize differences in altitude. A comparison of the shrub and fern layers shows many species in common, though the richness and importance of the tall shrub layer in the Tasmanian association is in marked contrast.

The two areas have another feature in common, the presence of subantarctic rain forest in the 'gullies'. On Mt. Wellington these gullies are of course very small in comparison with the wide valleys, whose sides are occupied by this formation in the other case.

The ecological position of *E. viminalis* in these areas and at Kosciusko is worthy of special attention. At the latter place it forms an association with *E. Gunnii* (*E. glaucescens*), while at Barrington it forms an association with *E. obliqua*. On Mt. Wellington it occurs occasionally in the driest portions of the *E. obliqua-regnans* association and in the more sheltered portions of the open forest, but cannot compete with *E. regnans* or *E. globulus* in the regions of higher moisture. Thus it occupies a very minor ecological position in south-east Tasmania, though it forms an important element in other parts. It is interesting to note that at Barrington it cannot compete with *E. fastigata*, which is closely related to *E. regnans*.

Its ecological position has brought *E. viminalis* frequently in contact with *E. globulus*, *E. salicifolia*, etc., with which it has hybridized freely (Brett, 1938). Another ecological juxtaposition which may have produced similar results in the distant past is shown by the case of *E. Johnstoni*, which is suspected by Brett (1938) of having arisen as the result of the stabilization of a hybrid between *E. subcrenulata* and *E. globulus*. Mt. Wellington is one of the few places in Tasmania where the montane dolerite talus, characterized by *E. subcrenulata*, has made contact with the upper edge of the *E. globulus* community. This would at least bring the two species in contact and go some distance to explaining the absence of *E. Johnstoni* from similar habitats on the central mountains. On Mt. Wellington, *E. Johnstoni* is scattered through the *E. urnigera* range, with which it has probably hybridized (Brett, 1938).

#### (4) Open Forest Association of the Lower Slopes

The study of ecology of the Eucalypts of this region has not been attempted; the problem is essentially one for the specially trained Eucalyptologist. Primarily distribution is a matter of varying degrees of xeromorphism, the order of increasing drought resistance being, *E. globulus*, *E. obliqua*, *E. viminalis*, *E. linearis*, *E. salicifolia*, *E. tasmanica*. However, the existence of complex hybrid swarms connecting two or more species, together with considerable denudation, would make the task of greater than its ecological importance warrants. The shrub and herb species are typical of the open forests of south-east Australia.

#### The Austral-Montane Formation

This may be divided into three main parts:

##### (a) Shrubberies

These consist of masses of low shrubs, occupying the small patches of soil amongst the large masses of boulders. The important elements are all 'Australian' (Maiden, 1914). Herbs belonging to the sub-antarctic element occur, but they play little part in the maintenance of the community. The important feature of the

vegetation is its extreme xeromorphism. This is a response to the edaphic and climatic conditions, which preclude the establishment of any mesophytic perennials. This has meant the sifting out of many of the types characteristic of the more complete development of the formation in other parts. The shrubberies of alpine conifers, *Phacrosphacra Diselma*, *Microcachrys* and of *Nothofagus Gunnii* and *N. Cunninghami*; trees of *Arthrotaxis* spp. are absent. There is also no solid mat of herb mosaics and only one 'bolster' plant is present.

It thus represents a marked contrast to Mt. Field, only 30 miles to the west, where at a slightly higher altitude with heavier rainfall and deeper and more lasting snow, these communities are fully developed.

#### (b) Swamps

The swamps bear some resemblance to those of Barrington Tops and Kosciusko, and many species are common to all three, e.g., *Hypolaena laterifolia*, *Restio australis*, *Euphrasia collina*, *Epacris scirpillofolia*, *Orcomyrrhus undicola*. Also the waterlogging of the soil affects the advance of the Eucalypt formation similarly. However, the local community presents several important differences. *Sphagnum* does not appear to play as important a part in the succession. This occurs free-floating in many of the pools and as occasional mounds in the more mature part, but development is not extensive. The inclusion of *Astelia* as a very important element makes the character of the vegetation entirely different; its thick stiff leaves and matted habit provides a firm basis, which the other elements, *Gleichenia dicarpa*, *Restio australis*, *Hypolaena laterifolia*, bind together in a solid mass. This is often firm and dry enough to permit shrubs such as *Richea* spp., *Orites acicularis*, etc., to maintain a semiepiphytic existence. *Baeckia Gunniana* plays a very much more, and *Epacris* spp. a very much less, important part in the succession on Mt. Wellington than in the other places. The position of *Abrotanella Fosterioides* is dealt with.

The problem of deciding what climatic sifting has maintained *Astelia alpina* in its important position in the Austral-Montane formation in Tasmania and prevented its appearance at Kosciusko and Barrington is an interesting one.

#### (c) Grassland

The *Poa cacaspitosa* grassland appears to have two origins, the first as a phase in the succession from the swamp to the *E. coccifera* consociation as a result of the slow draining of the swamp, and secondly as a probable subclimax in the higher parts on shallow, but well-drained, soils where accumulation from weathering is balanced by denudation. Shrubs are well represented and a certain number of other herbs and annuals, but the latter are more frequent in the grassland swamp ecotone.

#### Comparison with Cradle Mt. (Sutton, 1929)

The higher average rainfall of Cradle Mt. has permitted the development of a more complete Austral-Montane formation, which includes all those species which are excluded by the drier conditions from Mt. Wellington and having in greater quantities those plants which are rare there. In addition, Cradle Mt. supports a microthermal rain forest formation of the West Coast type and a Button Grass association. The grassland associations are practically identical, while the *E. coccifera* consociation is enriched by the greater development of *Nothofagus Cunninghami* and the presence of *N. Gunnii* and *Phyllocladus rhomboidialis* and other species all indicative of better water conditions.

The Hartz Mts., 30 miles S.W. of Hobart, provide another comparison of the influence of climate on floral composition in Tasmania. These mountains receive rainfall intermediate between that of Cradle Mt. and Mt. Wellington, while there

is probably little difference in the winter temperatures of the two places. In response to those conditions, the vegetation has developed an intermediate composition. *Arthrotaxis* does not develop in the microthermal rain forest, but is restricted to the edge of the alpine lakes; the shrubberies of alpine conifers and the level plant mosaics are present but poorly developed; on the other hand these other species such as *Milligania* sp. and *Aciphylla procumbens*, etc., which are absent from Mt. Wellington, do occur. The microthermal rain forest is quite extensive in the upper parts of the valleys draining the area, but not as rich as this formation at Cradle Mt.

#### Ecological Relationships of the Formations

All available evidence goes to show that it is the amount of available water which holds the balance between the Eucalyptus formation and the microthermal rain forest and Austral-Montane formations. In the first case the climate at 2000-3000 ft. is too dry to permit the advance of the microthermal rain forest beyond the sheltered gullies. The balance is not very much in favour of the Eucalypt, for the presence of occasional *Nothofagus* trees in the *E. regnans* forest and the difficulty of replacement of the Eucalyptus trees in the shady tall shrub layer, indicate that it would not require a great increase in rainfall or rainfall reliability to permit the advance of the *Nothofagus* community, with a lower light requirement into the other formation.

In the second case, towards the summit there is no question of the light factor playing any part, and the advance of Eucalypt formation into the Austral-Montane is restrained by poor water-supply, due to edaphic conditions or to exposure to wind in the case of the shrubberies and grassland, or by excessive water in the case of the swamps. It is very unlikely that low temperatures play any significant part in Eucalypt distribution on the summit.

#### GENERAL SUMMARY

The area studied includes the eastern end of the Mt. Wellington range between 800 and 4166 ft. (with a brief description of the open forest outside this area), lying about 5 miles west of Hobart (lat. 42° 54', long. 147° 17'). The mass consists of a dolerite sill, approx. 1600 ft. thick, overlying sandstones and mudstones.

The rainfall varies with altitude from 24" to approx. 60" per annum.

At higher altitudes the soils are high moor and skeletal types, and below 2500 ft. podsol types. The upper portion of the mountain is very rocky and the soil thin or scanty.

Three plant formations (two in reduced form) are represented:

1. Eucalypt forest.
2. Microthermal rain forest.
3. Austral-Montane.

The Eucalypt forest ranges from open forests of the drier low altitudes through dense forests of large trees with an important tall shrub layer to stunted, fairly open, montane-subalpine forest on the summit plateau.

The microthermal rain forest exists as a 'gully flora' in the upper parts of the large tree forests.

The Austral-Montane formation occupies the small area on the summit plateau not occupied by dwarf Eucalypt forest.

The Eucalypt forest has been divided into four types:

- (a) *E. coccifera* consociation with low shrubs (3500-4000 ft.)
- (b) *E. coccifera-urnigera* association with tall and low shrubs (2400-3500 ft.).

- (c) *E. obliqua-regnans* association with dense tall shrub layer (app. 1000-2500 ft.) and with 'gully' and sandstone communities.
- (d) Open forest associations occupying the tops and dryer sides with *E. globulus* communities on the moister sides of the ridges below 1000 ft.

Associations (a), (b), and (c) have been described briefly and compared and contrasted with Eucalyptus associations at Kosciusko and Barrington Tops. A very brief description of association (d) is also given. The 'gully flora' and sandstone communities within the Eucalyptus formation have been described. The relation of this formation with the reduced microthermal rain forest and Austral-Montane formations has been discussed briefly.

The relations of the reduced montane flora of Mt. Wellington to that of other mountains in Tasmania and the sifting effect of climate (mainly rainfall) on its composition are described.

A census of the plant species in the area is presented.

#### ACKNOWLEDGMENTS

This work was carried out at the request of the Committee of the Biological Survey of Tasmania, to whose help and encouragement its completion is due. I wish to express my thanks to Dr. A. N. Lewis for the information concerning the geology of the area, to Mr. C. G. Stephens of the Waite Institute for the section on the soils, to Mr. R. G. Brett for advice on the Eucalypts, to Mrs. O. Rodway for assistance in compiling the census, and to Dr. L. R. Fraser for much general advice and helpful criticism. Mr. J. J. N. Barnett has generously given permission to use the three copyright photographs in Plate I.

It is desired to acknowledge the advantage of having been able to study the manuscript of the paper by Mr. N. C. W. Beadle, M.Sc., on the vegetation of the area.

#### REFERENCES

- BEADLE, N. C. W., 1935.—Some Notes on the Ecology of Mt. Wellington, Tas. *Science Journal* (Sydney Univ.), Michelmas Issue.
- BLAKELY, W. F., 1934.—A Key to the Eucalypts, Sydney. The Workers Trustees Press.
- BRETT, R. G., 1938.—A Survey of the Eucalypt Species in Tasmania. *Pap. Roy. Soc. Tasm.*, 1937 (1938), pp. 75-110.
- BROUGH, P., MCLUCKIE, J., and PETRIE, A. H. K., 1924. An Ecological Study of the Flora of Mt. Wilson. *Proc. Linn. Soc. N.S.W.*, xlix, (4), 1924.
- FRASER, L. R. and VICKERY, J. W., 1937-1939.—The Ecology of the Upper Williams River and Barrington Tops Districts. *Proc. Linn. Soc. N.S.W.*, lxi, (5 & 6), pp. 269-283, lxii, (3 & 4), pp. 139-184; lxiv, (1 & 2), pp. 1-33.
- GIBBS, L. S., 1920.—Notes on the Phytogeography and Flora of the Mountain Summit Plateaux of Tasmania. *Journ. Ecology*, viii, 1, pp. 1-17, 2, pp. 89-117.
- HERBERT, D. A., 1935.—The Climatic Sifting of Australian Vegetation. *Report Aust. N.Z. Assoc. Adv. Sci.*, xxii, pp. 349-370.
- , —, —, 1936.—An Advancing Beech Forest. *Queensland Naturalist*, x, (1), pp. 8-10.
- MAIDEN, J. H., 1914.—Australian Vegetation. Federal Handbook on Australia, *Brit. Assoc. Adv. Sci.*, pp. 163-209.
- MCLUCKIE, J. and PETRIE, A. H. K., 1927.—The Vegetation of the Kosciusko Plateau. *Proc. Linn. Soc. N.S.W.*, li, (3), pp. 187-221.
- MELVAINE, A. T., 1936.—A Check List of the N.S. Wales Pteridophytes. *Proc. Linn. Soc. N.S.W.*, lxi, (3 & 4), pp. 112-121.
- PIDGEON, I. L., 1938.—The Ecology of the Central Coast Area of N.S. Wales. *Proc. Linn. Soc. N.S.W.*, lxiii, (1-2), p. 1.
- SUTTON, C. S., 1929.—A Sketch of the Vegetation of the Cradle Mt. and a Census of its Plants. *Pap. Roy. Soc. Tasm.*, 1928 (1929), pp. 132-159.



## APPENDIX

The following table has been compiled as the result of observation and collecting over a period of years.

Column 1. Austral-Montane formation of the summit plateau,

- „ 2. *E. coccifera* consociation,  
 „ 3. *E. coccifera-urnigera* association,  
 „ 4. *E. obliqua-regnans* association,  
 „ 5. Sandstone communities,  
 „ 6. Gully communities,  
 „ 7. Open forest association.

Abbreviations, vc = very common, c = common, lc = locally common.  
 f = frequent, o = occasional, r = rare, vr = very rare.

In order to increase the usefulness of the census, plants recorded by reliable collectors but not observed by the author have been included and marked with an asterisk (\*). For sections 1-6 the list may be regarded as fairly complete, but in the case of the open forest association, 7, there may be many omissions, not only because the association lay outside the area studied in more detail but also because it has been greatly altered by the proximity of Hobart and many aliens occur.

The terminology of Ewart's Flora of Victoria and Black's Flora of South Australia has been generally adopted except for the Filices, where that of Melvaine (1936) was used.

Gramineae	1	2	3	4	5	6	7
* <i>Agrostis alba</i> L.	..						
<i>parviflora</i> R.Br.		r	vr	vr	o	—	—
<i>Anthoxanthum odoratum</i> L. up to 3000'							
* <i>Arrhenantherum elatius</i> L.							
* <i>Calamagrostis minor</i> Benth.							
<i>Cynosurus cristatus</i> L. up to 2500'							
<i>Dactylis glomerata</i> L. up to 2500'							
* <i>Danthonia pallidax</i> R.Br.	—			c	—	—	c
<i>pauciflora</i> R.Br.	r	r	r	o	—	—	—
<i>racemosa</i> R.Br.	—	—	r	c	—	—	c
<i>semiannularis</i> R.Br.	—	—	—	c	—	—	vc
* <i>Deyeuxia accidens</i> J. Vickery							
* <i>Benthamiana</i> J. Vickery							
* <i>densa</i> Benth.							
* <i>monticola</i> (R & S). J. Vickery							
* <i>quadrisepta</i> (Lab). Benth.							
* <i>Rodwayi</i> J. Vickery							
* <i>scaberula</i> J. Vickery							
<i>Dichelachne crinata</i> Hook.	—	—	—	o	—	—	—
<i>Hierochloa Fraseri</i> Hook.	c	o	r	—	—	—	—
<i>redolens</i> R.Br.	o	o	o	c	—	—	—
<i>Holcus lanatus</i> L.	—	—	f	vc	o	—	c
* <i>Melia californica</i> Nell.							
<i>Microlaena stipitoides</i> R.Br.	—	—	o	—	—	—	c
<i>tasmanica</i> R.Br.							
var. <i>subalpina</i>	vr	—	—	—	—	—	—
* <i>Pentapogon quadrifidus</i> Baill.							
<i>Stipa aphylla</i> Rodway	—	—	—	—	—	—	o
<i>setacea</i> R.Br.	—	—	—	c	—	—	—
<i>Themeda triandra</i> Forsk.	—	—	—	c	—	—	vc
Cyperaceae							
<i>Carpha alpina</i> R.Br.	vc	o	o	—	—	—	—
<i>Carex breviculmis</i> R.Br.	—	—	—	—	—	—	r
<i>gaudichaudiana</i> Kunth.	—	—	—	o	—	—	r
<i>longifolia</i> R.Br.	—	—	—	o	—	f	o
* <i>tasmanica</i>	—	—	—	—	—	—	r

	1	2	3	4	5	6	7
<i>Gahnia graminifolia</i> Rodway	—	—	—	o	o	—	o
<i>psittacorum</i> Lab.	—	—	f	c	c	c	f
<i>radula</i> Benth.	—	—	—	o	o	—	—
<i>Lepidosperma filiforme</i> Lab.	—	—	—	vr	—	—	r
<i>elatus</i> Lab.	—	—	—	—	—	—	—
var. <i>Oldfieldii</i>	—	—	—	o	—	—	o
<i>laterale</i> R.Br.	—	—	—	r	—	—	o
<i>lineare</i> R.Br.	—	—	—	—	—	—	—
var. <i>inopk.</i>	—	—	—	r	—	—	o
<i>squamata</i> Lab.	—	—	—	o	o	—	f
<i>Oreobolus pumilio</i> R.Br.	f	—	—	—	—	—	—
* <i>Scirpus cernuus</i> Vahl	—	—	—	o	—	—	—
<i>crassiculatus</i> Hook.	f	—	—	—	—	—	—
<i>fluitans</i> L.	—	—	—	r	—	—	—
<i>inundatus</i> Spreng	o	—	—	f	—	—	—
<i>setaceus</i> L.	—	—	—	r	—	—	—
* <i>Schorrus apogon</i> R. & S	—	—	—	—	—	—	r
* <i>axillaris</i> Hook	—	—	—	r	—	—	—
<i>tenuissimus</i> Benth	—	—	—	r	o	—	—
<i>Uncinia compacta</i> R.Br.	f	1	r	—	—	—	—
<i>riparia</i> R.Br.	—	—	—	—	—	1	—
<i>tenella</i> R.Br.	1	—	—	o	r	—	—
Restionaceae							
<i>Hypolaena laterifolia</i> Benth.	ve	c	f	f	f	—	—
<i>Restio australis</i> R.Br.	lc	—	—	—	lc	—	—
* <i>complanatus</i> R.Br.	—	—	—	—	—	—	—
* <i>oligocephalus</i> F v M.	—	—	—	—	—	—	—
Centrolepidaceae							
<i>Centrolepis aristata</i> R & S	—	—	—	—	o	—	o
<i>fascicularis</i> Lab.	—	—	—	—	r	—	1
<i>strigosa</i> R & S	—	—	—	—	o	—	1
Juncaceae							
<i>Juncus bufonius</i> L.	—	—	—	o	o	—	1
<i>communis</i> Mey.	—	—	—	lc	—	—	lc
<i>pallidus</i> R.Br.	—	—	—	o	—	—	—
<i>planifolius</i> R.Br.	—	—	—	f	—	—	f
<i>pauciflorus</i> R.Br.	—	—	—	o	—	—	o
<i>prismatocarpus</i> R.Br.	—	—	—	r	—	—	o
<i>Luzula campestris</i> D.C.	o	—	r	f	—	—	r
( <i>Oldfieldii</i> Hook.	c	o	r	—	—	—	—
Liliaceae							
<i>Anguillaria dioica</i> R.Br.	—	—	—	o	—	—	—
<i>Arthropodium paniculatum</i> R.Br.	—	—	—	—	—	—	o
<i>Antelia alpina</i> R.Br.	ve	lc	o	—	—	—	—
<i>Bulbine bulbosa</i> Haw.	—	—	—	o	—	—	o
<i>Dianella revoluta</i> R.Br.	—	—	—	o	o	—	f
<i>tasmanica</i> Hook.f.	—	—	vi	c	c	—	—
<i>Drymophora cyanocarpa</i> R.Br.	—	—	—	f	c	—	—
<i>Stypandracaspitosa</i> R.Br.	—	—	—	—	—	—	o
<i>Thysanotus Patersoni</i> R.Br.	—	—	—	—	—	—	o
<i>Xerotes longifolia</i> R.Br. ( <i>Lomandra</i> )	—	—	—	o	—	—	ve
Amaryllidaceae							
<i>Hypoxis hygrometrica</i> Lab.	—	—	—	—	—	—	o
Iridaceae							
<i>Diplarrhena moraea</i> Lab.	—	—	—	c	—	—	ve
Orchidaceae							

N.B.—All the members of this family in the area are geophytes. It is difficult to form a reliable estimate of the frequency, and many species recorded as occasional or rare may become locally common.

<i>Acianthus caudatus</i> R.Br.		r			f			o
* <i>exsertus</i> R.Br.								o
* <i>reniformis</i> R.Br.								r
<i>viridis</i> Hook.					f			o
<i>Caladenia angustata</i> Lindl.		r	r	o	r			r
<i>carnea</i> R.Br.				o				o
<i>dilatata</i> R.Br.				o				f
* <i>filamentosa</i> R.Br.								r
* <i>Patersoni</i> R.Br.								r
* <i>suaveolens</i> Reichb.								r
* <i>testacea</i> R.Br.								r
<i>Calcana major</i> R.Br.								o
<i>minor</i> R.Br.								o
* <i>Calochilus campestris</i> R.Br.								o
<i>Chilogottis Gunnii</i> Lindl.				vr				
<i>Cryptostylis reniformis</i> Lindl.								r
<i>Dipodium punctatum</i> R.Br.				vr		vr	vr	
<i>Diuris maculata</i> Sm.								f
* <i>pedunculata</i> R.Br.								o
* <i>palustris</i> Lindl.								r
<i>sulphurea</i> R.Br.								f
<i>Eriochilus cucullatus</i> (Lab.) Reichb.								r
<i>Gastrodia sesamoides</i> R.Br.				r		r	vr	
<i>Glossodia major</i> R.Br.								f
<i>Microtis porrifolia</i> R.Br.								o
* <i>Pterostylis barbata</i> Lindl.								r
* <i>cucullata</i> R.Br.	vr	vr	vr	r	r			o
<i>longifolia</i> R.Br.				r	f			f
<i>nutans</i> R.Br.	1			o				o
<i>obtusata</i> R.Br.				r	r			r
* <i>parviflora</i> R.Br.								r
* <i>rufa</i> R.Br.								r
* <i>squamata</i> Lindl.								r
<i>Prasophyllum australe</i> R.Br.				r				o
* <i>brachystachyum</i> Lindl.								r
* <i>dissectans</i> Hook.f.								r
<i>elatum</i> R.Br.								r
* <i>brevilabre</i> Hook.f.				1				o
<i>fuscum</i> R.Br.	o			o	r			o
<i>nigricans</i> R.Br.				r				o
* <i>patens</i> R.Br.	1			o				o
* <i>rufum</i> R.Br.								r
<i>Spiranthes australis</i> Lindl.								vr
<i>Thelymitra carnea</i> R.Br.								o
<i>ixiodes</i> Sw.								o
<i>venosa</i> R.Br.				r				o
Bulmanniaceae								
* <i>Thiisia Rodwayi</i> F.v.M.							vr	

## DICOTYLEDONS

Casurinaeae								
<i>Casurina stricta</i> Ait.								lc
Fagaceae								
<i>Nothofagus Cunninghamii</i> Hook. f. Oers.				lc		c		
Proteaceae								
<i>Banksia marginata</i> Cav.			o	c	o			c
<i>Bellenden montana</i> R.Br.	vc	c	o					
<i>Grevillea australis</i> R.Br.		vr	vr					
<i>Hakea sericea</i> Sch.				c	o			
var. <i>lanceoliformis</i>					o	o		
<i>epiglottis</i> Lab.			vr	vr				
<i>Lomatia polymorpha</i> R.Br.	vr	vr	vr					
<i>tinctora</i> R.Br.			o	vc	c			vc

	1	2	3	4	5	6	7
<i>Orites acicularis</i> R.Br.	ve	c	—	—	—	—	—
<i>diversifolia</i> R.Br.	—	r	f	o	—	—	—
<i>revoluta</i> R.Br.	c	c	r	—	—	—	—
<i>Persoonia juniperina</i> R.Br.	—	—	—	r	—	—	o
<i>Telopea truncata</i> R.Br.	—	o	c	r	—	—	—
<b>Santalaceae</b>							
<i>Ezocarpus cupressiformis</i> Lab.	—	—	—	f	—	—	f
<i>humifusa</i> R.Br.	c	o	—	—	—	—	—
<i>stricta</i> R.Br.	—	—	—	f	—	—	f
<i>Leptomeria Billardieri</i> R.Br.	—	—	—	r	—	—	o
<b>Malvaceae</b>							
<i>Plagianthus sidiodes</i> H.	—	—	—	o	—	o	—
<b>Portulacaceae</b>							
* <i>Claytonia australasica</i> H.	—	—	—	—	—	—	—
<b>Caryophyllaceae</b>							
* <i>Moenchia flaccida</i> H.	vr	—	—	—	—	—	—
<i>Stellaria flaccida</i> H.	—	—	—	o	—	—	—
<b>Ranunculaceae</b>							
<i>Clematis aristata</i> R.Br.	—	—	—	f	—	f	—
<i>gentianoides</i> D.C.	—	—	—	—	—	—	o
<i>Ranunculus hirtus</i> Banks & Sol.	—	—	f	f	—	—	—
<i>lappaceus</i> Sm.	—	—	—	f	—	o	o
*I <i>parviflorus</i> Ehr.	—	—	—	—	—	—	—
*I <i>philonotis</i> Ehr.	—	—	—	—	—	—	—
*I      var. <i>pimpernellifolius</i>	—	—	—	—	—	—	—
* <i>rivularis</i>	—	—	—	—	—	—	—
*      var. <i>inundatus</i>	—	—	—	—	—	—	—
<b>Winteraceae</b>							
<i>Drimys lanceolata</i> (Poir.) Baill.	f	c	c	f	o	o	—
<b>Monimiaceae</b>							
<i>Atherosperma moschatum</i> Lab.	—	—	vr	r	—	ve	—
<b>Cruciferae</b>							
I <i>Brassica sinapistrum</i> Boiss.	—	—	—	o	—	—	—
<i>Cardamine hirsuta</i> L.	—	—	—	o	—	—	—
var. <i>tenuifolia</i> H.	f	f	f	o	—	—	o
<i>stylosa</i> D.C.	—	—	—	r	—	—	—
<b>Lauraceae</b>							
<i>Cassytha pubescens</i> R.Br.	—	—	—	o	—	—	f
<b>Pittosporaceae</b>							
<i>Billardiera longiflora</i> Lab.	—	—	—	f	—	—	o
*      var. <i>alpina</i>	—	—	r	—	—	—	—
<i>Bursaria spinosa</i> Cav.	—	—	—	—	—	—	ve
<i>Marianthus procumbens</i> B.	—	—	r	—	—	—	o
<i>Pittosporum bicolor</i> H.	—	r	f	f	—	f	—
<b>Saxifragaceae</b>							
<i>Anopterus glandulosus</i> Lab.	—	—	—	o	—	o	—
<i>Bauera rubioides</i> Andr.	f	f	c	r	o	—	—
<i>Tetracarpaea tasmanica</i> H.	o	r	r	—	—	—	—
<b>Rosaceae</b>							
<i>Acaena ovina</i> Cunn.	—	—	—	—	—	—	o
<i>sanguisorba</i> Vahl.	o	o	c	ve	c	—	c
var. <i>montana</i>	r	—	—	—	—	—	—

	1	2	3	4	5	6	7
I <i>Rubus fruticosus</i> L.	—	—	—	o	—	o	c
<i>Gunnianus</i> H.	....	o	o	o	—	—	—
<i>parvifolius</i> L.	..	—	—	f	—	—	o
<b>Droseraceae</b>							
<i>Drosera arcturi</i> H.	.	f	—	—	—	—	—
<i>auriculata</i> Back		—	—	o	f	—	c
<i>binata</i> Lab.		—	—	o	f	—	—
<i>pygmaea</i> D C.		—	—	o	o	—	—
<b>Leguminosae</b>							
<i>Acacia dealbata</i> Link.	..	—	—	ve	—	f	ve
<i>decurrens</i> Willd.	.	—	—	o	—	—	ve
<i>diffusa</i> Lindl.		—	—	o	—	—	c
<i>discolor</i> Willd.		—	—	f	—	—	f
<i>melanoxydon</i> R.Br.		—	—	c	—	c	o
<i>myrtifolia</i> Willd.		—	—	—	—	—	c
<i>riceana</i> Hens.	.	—	—	o	o	—	f
<i>verniciflua</i> A. Cunn.		—	—	ve	c	o	f
<i>verticillata</i> Willd.		—	—	o	o	—	lc
<i>vomeriformis</i> A. Cunn.		—	—	—	—	—	f
<i>stricta</i> Willd.		—	—	—	—	—	c
<i>Aotus villosa</i> Sm.		—	—	o	o	—	c
<i>Bossiaea prostrata</i> R.Br.		—	—	—	—	—	f
<i>Daviesia latifolia</i> R.Br.		—	—	o	o	o	lc
<i>ulicina</i> Sm.		—	—	o	—	—	lc
<i>Dillwynia cinerascens</i> R.Br.	..	—	—	o	—	—	f
<i>floribunda</i> Sm.		—	—	o	—	—	c
<i>Goodia lotifolia</i> Salisb.	.	—	—	o	—	—	r
<i>Hovea heterophylla</i> Cunn.		—	—	—	—	—	o
<i>Indiaphora australis</i> Willd.		—	—	o	—	—	o
<i>Kennedya prostrata</i> R.Br.		—	—	—	—	—	c
<i>Pultenea daphnoides</i> Wend.		—	—	c	—	—	c
* <i>dentata</i> Lab.		—	—	—	—	—	r
<i>Gunnii</i> Benth.	..	—	—	o	—	—	f
var <i>baerhodes</i>		—	—	o	—	—	o
<i>juniperina</i> Lab.		—	—	ve	—	—	ve
<i>stricta</i> Sims.		—	—	o	—	—	f
<i>tenuifolia</i> R.Br.		—	—	—	—	—	vr
<i>Oxylobium ellipticum</i> R.Br.	.. ....	—	o	o	ve	ve	o
<i>Sphaerolobium vimineum</i> Sm.		—	—	—	—	—	r
I <i>Trifolium agrarium</i> L.							
I <i>glomeratum</i> L.							
I <i>pratense</i> L.							
I <i>repens</i> L.							
I <i>Ulex europaeus</i> L.							
<b>Geraniaceae</b>							
<i>Geranium dissectum</i> L.	.	f	f	c	c	—	f
<i>sessiflorum</i> Cav	.	o	o	o	—	—	o
<i>Perlargonium australe</i> Willd.	..	—	—	—	r	—	r
<b>Oxalidaceae</b>							
<i>Oxalis magellanica</i> Forst.	.. . . . .	r	o	o	o	—	—
<b>Rutaceae</b>							
<i>Boronia pilosa</i> Lab.	.	—	—	vr	—	—	o
<i>pinnata</i> Sm	.	—	—	r	—	—	f
* <i>polygalifolia</i> Lab.	.	—	—	—	—	—	vr
<i>Correa rubra</i> Sm.	.	—	o	c	c	o	r
<i>Laurenciana</i> Hook.	.	—	o	c	f	o	r
<i>Eriostemon obovatus</i> Cunn.	.. . . .	—	—	—	—	—	f
<i>Phebalium squameum</i> Lab.	. . . . .	—	—	—	ve	ve	c
<i>Zieria Smithii</i> Andr.	. . . . .	—	—	—	c	—	f

		1	2	3	4	5	6	7
<b>Stackhousiaceae</b>								
<i>Stackhousia</i>	<i>linearifolia</i> A. Cunn		1	1	0	—	—	f
<b>Rhamnaceae</b>								
<i>Pomaderris</i>	<i>apetala</i> Lab.	—	—	—	vc	0	vc	r
*	<i>elaeophylla</i> F.v.M.							
	<i>elliptica</i> Lab.		—	—	—	—	—	c
*	<i>racemosa</i> Hook.							
<i>Spryidium</i>	<i>ulcinum</i> Benth.	—	—	—	—	—	—	vr
<b>Sapindaceae</b>								
<i>Dodonaea</i>	<i>viscosa</i> L.	—	—	—	f	—	—	1
<b>Linaceae</b>								
I	<i>Linum catharticum</i> L.	—	—	—	—	—	—	0
I	<i>gallicum</i> L.	—	—	—	—	—	—	0
<b>Urticaceae</b>								
* <i>Australina</i>	<i>Muelleri</i> Wedd	—	—	—	1	—	1	—
	<i>pusilla</i> Gaud.	—	—	—	1	—	r	—
<i>Urtica</i>	<i>incisa</i> Poir.	—	—	—	1	—	1	—
<b>Polygalaceae</b>								
<i>Bredemeyera</i>	<i>retusum</i> (Steetz). Chod		—	—	0	—	—	0
	<i>volubile</i> (Steetz). Chod.	—	—	—	f	—	—	c
<b>Euphorbiaceae</b>								
<i>Amperea</i>	<i>spartodes</i> Bron	—	—	—	c	c	—	v
<i>Beyeria</i>	<i>viscosa</i> Miq	—	—	—	c	—	c	lc
* <i>Poranthera</i>	<i>microphylla</i> Bron	0	—	—	—	—	—	—
<i>Solanaceae</i>								
<i>Solanum</i>	<i>ariculare</i> Forst.	—	—	—	r	—	vr	—
<b>Tremandraceae</b>								
<i>Tetratheca</i>	<i>glandulosa</i> Lab	—	—	—	1	—	—	vc
	<i>pilosa</i> Lab	—	—	—	1	—	—	vc
<b>Elaeocarpaceae</b>								
<i>Aristotelia</i>	<i>peduncularis</i> Hook.	—	—	0	f	—	—	f
<b>Dilleniaceae</b>								
<i>Hibbertia</i>	<i>fasciculata</i> R.Br.	—	—	—	—	0	—	f
	<i>hirsuta</i> Benth	—	—	—	—	—	—	0
	<i>procumbens</i> D.C.	—	—	—	—	—	—	0
	<i>stricta</i> R.Br.	—	—	—	1	0	—	f
<b>Guttiferae</b>								
I*	<i>Hypericum androsaemum</i> L.	—	—	—	—	—	—	r
	<i>graminum</i> Forst	—	—	—	1	0	—	0
I*	<i>japonicum</i> Thunb.	—	—	—	—	—	—	r
<b>Violaceae</b>								
<i>Viola</i>	<i>hederacea</i> Lab	—	e	r	0	r	0	f
<b>Thymeliaceae</b>								
<i>Pimelia</i>	<i>cinerea</i> R.Br.	—	—	—	1	—	—	0
	<i>drupacea</i> Lab.	—	—	—	c	—	f	—
	<i>flava</i> R.Br.	—	—	—	r	—	—	0
	<i>nivea</i> Lab.	—	—	1	lc	0	—	c
	<i>serecea</i> R.Br.	c	0	1	—	—	—	—
*	<i>involuta</i> Banks & Sol.	—	—	—	—	—	—	0
*	<i>humilis</i> R.Br.	—	—	—	—	—	—	r
<b>Myrtaceae</b>								
<i>Baeckia</i>	<i>Gunniana</i> Schau.	vc	f	—	—	—	—	—
*	<i>ramosissima</i> A. Cunn.	—	—	—	—	—	—	vr

	1	2	3	4	5	6	7
<i>Callistemon salignus</i> D.C.	—	—	—	o	o	—	—
<i>Eucalyptus coccifera</i> Hook.f.	—	d	sd	—	—	—	—
<i>cordata</i> Lab.	—	—	—	—	—	—	l
<i>gigantea</i> Hook.f.	—	—	f	ld	c	—	—
<i>globulus</i> Lab.	—	—	—	lf	—	—	ld
<i>Johnstoni</i> Maiden.	—	—	c	o	d	—	—
<i>linearis</i> Dehn.	—	—	—	—	—	—	vc
<i>obliqua</i> L'Her.	—	—	—	d	c	—	lc
<i>ovata</i> Lab.	—	—	—	r	—	—	o
<i>regnans</i> F.v.M.	—	—	—	d	r	vr	—
<i>salicifolia</i> (Sol) Cav.	—	—	—	—	—	—	vc
<i>tasmanica</i> Blakely	—	—	—	—	—	—	vc
<i>unialata</i> Baker & Smith	—	—	—	—	—	—	—
<i>urnigera</i> Hook.f.	—	—	d	o	—	—	—
<i>viminalis</i> Lab.	—	—	—	r	—	—	vc
For information regarding the complex hybrid swarms see Brett (1938).							
<i>Leptospermum flavescens</i> Sm.	—	—	—	f	f	—	o
<i>lanigerum</i> Sm.	—	lc	lc	c	r	—	—
<i>rupestre</i> Hook.	ve	o	—	—	—	—	—
<i>scoparium</i> Forst.	—	—	—	o	vc	—	vc
<i>Melaleuca squamea</i> Lab.	—	—	—	—	lc	—	—
Onagraceae							
<i>Epilobium Billardierianum</i> Ser.	—	—	r	o	—	—	—
<i>confertifolium</i> Hook.f.	o	—	—	—	—	—	—
<i>Gunnianum</i> Haush.	o	o	f	f	—	—	—
<i>junceum</i> Forst.	—	—	c	o	o	—	o
Haloragidaceae							
* <i>Haloragis depressa</i> (A. Cunn.) Walp.	—	—	—	—	—	—	—
<i>micrantha</i> (R.Br.) Thunb.	r	r	r	—	—	—	—
<i>tetragyna</i> Hook.f.	—	—	—	—	—	—	—
<i>teucroides</i> D.C.	—	r	lc	lc	—	—	—
Umbelliferae							
* <i>Daucus glochidatus</i> (Fisch) Mey.	—	—	—	r	—	—	—
* <i>Eryngium vesiculosum</i> Lab.	—	—	—	—	—	—	—
* <i>Hydrocotyle hirta</i> R.Br.	—	—	—	—	—	—	—
* <i>Orreomyrrhis andicola</i> Endl.	r	—	—	—	—	—	—
* <i>Xanthosia dissecta</i> Hook.f.	—	—	—	—	—	—	—
* <i>pilosa</i> Rudge.	—	—	—	—	—	—	—
Ericaceae							
<i>Gaultheria hispida</i> R.Br.	—	r	c	c	o	o	—
Epacridaceae							
<i>Acrotiche serrulata</i> R.Br.	—	—	—	—	—	—	c
<i>Astroloma humifusum</i> R.Br.	—	—	—	—	—	—	c
<i>Brachyloma daphnoides</i> Benth.	—	—	—	—	—	—	f
<i>Cyathodes acerosa</i> R.Br.	—	o	c	c	o	—	o
<i>adscendens</i> Hook.	vc	c	r	—	—	—	—
<i>dealbata</i> R.Br.	o	—	—	—	—	—	—
<i>divaricata</i> Hook.	—	—	f	—	—	—	o
<i>glauca</i> R.Br.	—	o	c	c	o	—	—
<i>parvifolia</i> R.Br.	—	—	o	c	f	—	o
<i>Epacris impressa</i> Lab.	—	—	—	vc	vc	—	vc
<i>lanuginosa</i> R.Br.	—	—	—	—	r	—	r
<i>microphylla</i> R.Br.	—	—	—	—	r	—	o
<i>serpillifolia</i> R.Br.	f	o	—	—	—	—	—
* var. <i>squarrosa</i>	—	—	—	—	—	—	—
<i>Lissanthe montana</i> R.Br.	o	—	—	—	—	—	—
<i>strigosa</i> R.Br.	—	—	—	—	—	—	c
<i>Monotoca lineata</i> R.Br.	—	—	—	vc	vc	o	—
<i>empetrifolia</i> R.Br.	o	o	—	—	—	—	—

	1	2	3	4	5	6	7
<i>Pentachondra involucreta</i> R.Br.	o	r	vr	—	—	—	—
<i>pumila</i> R.Br.	vc	—	—	—	—	—	—
<i>Richea acerosa</i> F.v.M.	vc	c	—	—	—	—	—
<i>dracophylla</i> R.Br.	—	—	c	r	o	—	—
<i>Gunnii</i> Hook.	c	c	o	—	—	—	—
<i>procera</i> F.v.M.	o	o	o	o	o	—	—
<i>scoparia</i> Hook.	c	c	o	—	—	—	—
<i>sprengeloides</i> F.v.M.	o	o	r	c	c	—	c
<i>Sprengelia incarnata</i> F.v.M.	r	o	r	c	vc	—	vc
<i>Styphelia adscendens</i> R.Br.	—	—	—	—	o	—	—
<i>Trochocarpa thymifolia</i> Spreng.	vc	vc	f	—	—	—	—
<b>Oleaceae</b>							
<i>Notela ligustrina</i> Vent.	—	—	—	l	—	o	l
<b>Apocyanaceae</b>							
<i>Lyonisia straminea</i> R.Br.	—	—	—	r	—	r	—
<b>Loganiaceae</b>							
<i>Mitrasacme montana</i> Hook.	o	—	—	—	—	—	—
<i>pilosa</i> Lab.	—	—	—	o	—	—	—
<b>Gentianaceae</b>							
<i>Erythraea australis</i> R.Br.	—	—	—	o	—	—	—
<i>Gentiana dimensis</i> Greab.	f	o	o	o	—	—	—
<b>Horaginaceae</b>							
* <i>Myosoton australis</i> R.Br.	—	—	—	vr	—	—	—
<i>suaveolens</i> Poir.	r	—	—	—	—	—	—
<b>Labiatae</b>							
<i>Prostanthera lasianthos</i> Lab.	—	—	f	vc	—	c	—
1* <i>Stachys arvensis</i> L.	—	—	—	—	—	—	—
<i>Westringia rigida</i> R.Br.	—	—	—	o	—	—	—
<b>Scrophulariaceae</b>							
<i>Euphrasia collina</i> Hook.	—	—	—	f	—	—	c
var. <i>alpina</i> R.Br.	vc	c	c	—	—	—	—
var. <i>striata</i> R.Br.	—	o	o	o	—	—	—
<i>scabra</i> R.Br.	—	—	—	—	—	—	o
* <i>Mazun pumilo</i> R.Br.	—	—	—	—	—	—	—
* <i>Ourisia integrifolia</i> R.Br.	—	—	—	—	—	—	—
1* <i>Veronica agrestis</i> L.	—	—	—	—	—	—	—
1 <i>arvensis</i> L.	—	—	—	—	—	—	r
<i>formosa</i> R.Br.	—	t	c	c	—	—	f
<i>nivea</i> Lindl.	r	r	r	—	—	—	—
* <i>gracilis</i> R.Br.	—	—	—	—	—	—	r
1* <i>serpillifolia</i>	—	—	—	—	—	—	—
<b>Plantaginaceae</b>							
* <i>Plantago lanceolata</i> Linn.	—	—	—	c	—	—	c
<i>tasmanica</i> Hook.f.	o	—	—	—	—	—	—
<i>varia</i> R.Br.	—	—	—	o	—	—	d
<b>Rubiaceae</b>							
* <i>Asperula oligantha</i> F.v.M.	—	—	—	—	—	—	—
<i>Ceprosia Billardieri</i> Hook.f.	—	—	r	c	—	c	o
<i>hirtella</i> Lab.	—	—	o	c	—	—	o
<i>nitida</i> Hook.	f	c	c	—	—	—	—
<i>Moorei</i> Rodway	r	—	—	—	l	—	—
* <i>repens</i> Hook.	—	—	—	—	—	—	—
* <i>Opercularia varia</i> Hook.	—	—	—	—	—	—	r
<b>Campanulaceae</b>							
<i>Lobelia gibbosa</i> Lab.	—	—	—	—	—	—	r
<i>Whalenbergia gracilis</i> D.C.	—	—	—	o	—	—	l
<i>saxicola</i> D.C.	o	—	—	—	—	—	—



	1	2	3	4	5	6	7
<b>Goodeniaceae</b>							
<i>Goodenia geniculata</i> R.Br. . . . .	—	—	—	o	—	—	f
<i>ovata</i> Sm. . . . .	—	—	—	c	o	c	—
<i>Scaevola Hookeri</i> F.v.M. . . . .	r	—	—	—	—	—	—
<b>Candolleaceae</b>							
<i>Stylidium graminifolium</i> Swartz. . . . .	o	—	r	f	c	—	c
<b>Compositae</b>							
<i>Abrotanella Fosteri</i> R.Br. . . . .	o	—	—	—	—	—	—
<i>Brachycome melanocarpa</i> Sand. & F.v.M. . . . .	—	—	—	—	—	—	r
* <i>stipitata</i> Hook. . . . .	—	—	—	—	—	—	o
<i>Cassinia aculeata</i> R.Br. . . . .	—	—	—	o	—	—	o
<i>Celmisia longifolia</i> D.C. . . . .	ve	c	—	—	—	—	—
<i>Cotula filicula</i> Hook.f. . . . .	r	—	—	—	—	—	—
<i>Craepedia alpina</i> Hook. . . . .	ve	—	—	—	—	—	—
<i>uniiflora</i> Forst. . . . .	—	—	—	—	—	—	o
* <i>Cymbonotus Lawsoniana</i> Gaud. . . . .	—	—	—	—	—	—	r
<i>Bedfordia linearis</i> D.C. . . . .	—	—	—	—	—	—	ve
<i>salicina</i> D.C. . . . .	—	—	f	ve	o	d	l
<i>Erechtites arguta</i> D.C. . . . .	—	—	—	r	—	—	—
<i>Gunnii</i> Hook. . . . .	o	r	—	—	—	—	—
<i>prenanthoides</i> D.C. . . . .	—	—	—	r	—	—	—
<i>Erigeron pappochroma</i> Lab. . . . .	o	r	—	—	—	—	—
<i>Gnaphalium alpinum</i> F.v.M. . . . .	r	r	—	—	—	—	—
<i>indutum</i> Hook.f. . . . .	—	—	—	r	r	—	—
<i>Helichrysum apiculatum</i> D.C. . . . .	c	o	o	o	o	—	c
<i>dealbata</i> Lab. . . . .	—	—	—	—	—	—	r
<i>scorpioides</i> Lab. . . . .	c	o	o	c	o	—	c
<i>semipapposum</i> D.C. . . . .	—	—	—	—	—	—	—
<i>Lagenophora stipitata</i> Druce. . . . .	—	—	—	—	—	—	r
* <i>Leptorrhynchus linearis</i> Less. . . . .	—	—	—	—	—	—	r
* <i>squamatus</i> Less. . . . .	—	—	—	—	—	—	r
<i>Microseris Fosteri</i> Hook. . . . .	—	—	—	r	—	—	r
* <i>Millotia tenuifolia</i> Cass. . . . .	—	—	—	—	—	—	o
<i>Olearia argophylla</i> F.v.M. . . . .	—	—	—	ve	r	d	—
* <i>erubescens</i> Dipp. . . . .	—	—	—	—	—	—	—
<i>floribunda</i> Benth. . . . .	o	r	r	c	o	—	f
<i>glandulosa</i> Benth. . . . .	—	—	—	—	—	—	—
<i>Hookeri</i> Benth. . . . .	—	—	—	—	—	—	o
<i>ledifolia</i> Benth. . . . .	o	o	—	—	—	—	—
<i>lepidophylla</i> Benth. . . . .	r	vr	—	—	—	—	—
<i>myrsinoides</i> F.v.M. . . . .	—	—	r	f	o	—	o
<i>obcordata</i> Benth. . . . .	o	—	—	—	—	—	—
<i>persoonioides</i> Benth. . . . .	—	—	—	—	—	—	—
var. <i>alpina</i> . . . . .	o	o	r	—	—	—	—
var. <i>lanceolata</i> . . . . .	—	—	c	o	—	—	—
<i>pinifolia</i> Benth. . . . .	o	f	o	—	—	—	—
<i>ramulosa</i> Benth. . . . .	—	—	r	f	—	—	—
<i>stellulata</i> Benth. . . . .	—	f	ve	c	o	o	o
<i>viscosa</i> Benth. . . . .	—	—	o	f	o	—	f
<i>Ozothamnus antennaria</i> Hook. . . . .	o	o	o	—	—	—	—
<i>Backhousii</i> Hook. . . . .	o	r	—	—	—	—	—
* <i>ericifolius</i> Hook. . . . .	—	—	—	—	—	—	r
<i>Hookeri</i> Hook. . . . .	f	—	—	—	—	—	—
<i>ledifolius</i> Hook. . . . .	ve	f	r	—	—	—	—
<i>obcordatus</i> D.C. . . . .	—	—	—	—	—	—	f
<i>rosmarinifolius</i> D.C. . . . .	—	—	—	c	o	f	o
<i>scutellifolius</i> Hook. . . . .	—	—	—	—	—	—	r
<i>Gunnii</i> Hook. . . . .	r	—	—	—	—	—	—
* <i>Podolepis acuminata</i> R.Br. . . . .	—	—	—	—	—	—	r
<i>Raoulia planchonii</i> Hook. . . . .	r	—	—	—	—	—	—
<i>Senecio centropappus</i> F.v.M. . . . .	—	—	f	—	—	—	—
<i>dryadens</i> Sieb. . . . .	—	—	—	c	f	o	f
<i>lautus</i> Sol. . . . .	—	—	—	o	—	o	o

\**Senecio* var. *capillifolius*  
var. *octoleucus*  
    *velleyoides* A. Cunn.  
*Vittadinia australis* D.C.

1	2	3	4	5	6	7
—	—	—	o	—	o	o
f	o	o	o	—	—	—
—	—	—	o	—	—	—
—	—	—	—	—	—	o

## INTRODUCED

*Anthemis nobilis* L.  
*Bellis perennis* L.  
*Calendula officinalis* L.  
*Carduus arvensis* Scop.  
*Centipeda minima* (L.) Br. & Asch.  
*Chrysanthemum parthenium* Pers.

† *Gnaphalium luteo-album* D.C.  
*Hypocharris glabra* L.  
*Lapsana communis* L.  
*Picris hieracioides* L.  
*Sonchus oleraceus* L.  
*Taraxicum dens-leonis* Desf.

## CONIFERAE

*Phyllocladus rhomboidialis* Rich.  
*Podocarpus alpina* R.Br.

1	2	3	4	5	6	7
—	—	vr	—	—	—	—
lc	—	r	—	—	—	—

## PTERIDOPHYTA

## Lycopodiaceae

*Lycopodium clavatum*

var. *fastigiatum* L.  
    *densum* Lab.  
    *laterale* R.Br.  
    *scariosum* Forst.  
\* *selago* L.  
\* *varium* R.Br.

f	f	f	—	—	—	—
o	—	—	—	—	f	—
f	r	r	—	—	r	—
r	—	—	—	—	r	—
—	r	r	r	—	r	—
r	—	—	—	—	—	—

## Selaginellaceae

*Selaginella uliginosa* Spreng.

f	o	—	—	—	—	—
---	---	---	---	---	---	---

## Psilotaceae

*Tmesipteris tannensis* Bernh.

—	—	—	—	—	o	—
---	---	---	---	---	---	---

## Ophioglossaceae

\**Ophioglossum lusitanicum* L.

—	—	—	—	—	—	vr
---	---	---	---	---	---	----

## Osmundaceae

\**Todea barbara* (L.) Moore.

## Schizeaceae

*Schizra bifida* Willd.\* *fistulosa* Lab

—	—	—	r	r	—	—
---	---	---	---	---	---	---

## Gleicheniaceae

\**Gleichenia circinata* Sw.

*dicarpa* R.Br.

\* *flabellata* R.Br.

vc	c	o	o	—	o	—
—	—	vr	vr	—	—	—

## Hymenophyllaceae

*Hymenophyllum australe* Willd.

*flabellatum* Lab.

*javanicum* Spreng.

\* *peltatum* (Poir.) Dexv.\* *rarum*

*turhrigenae* (L.) Sm.

—	—	—	—	—	c	—
vr	—	—	—	—	c	—
—	—	—	—	—	o	—
—	—	—	—	—	o	—
—	—	—	—	—	r	—

## Dicksoniaceae

\**Alsophila australis* R.Br.

*Dicksonia antarctica* Lab.

*Hypolepis punctata* (Thunb.) Mett.

*tenuifolia* (Forst.) Bern.

—	—	—	vr	—	vr	—
—	—	—	c	—	vc	—
—	—	—	c	—	vc	—
—	—	—	r	—	o	—

Polypodiaceae	1	2	3	4	5	6	7
<i>Adiantum aethiopicum</i> L. . . . .	—	—	—	r	—	—	r
<i>Anogramma leptophylla</i> (L.) Link. . . . .	r	—	—	vr	—	—	—
<i>Asplenium bulbiferum</i> Forst. . . . .	—	—	—	o	—	c	—
<i>flabellifolium</i> Cav. . . . .	—	—	r	o	—	c	o
<i>flaccidum</i> Forst. . . . .	—	—	—	—	—	o	—
<i>Blechnum capense</i> (L.) Schlecht. . . . .	—	—	o	vc	c	vc	—
<i>discolor</i> (Forst.) Keys. . . . .	—	—	—	vc	—	c	—
<i>fluviatile</i> (R.Br.) Lett. . . . .	—	—	—	r	—	r	—
<i>lanceolatum</i> (R.Br.) Sturn. . . . .	—	—	—	c	—	c	—
<i>Patersoni</i> (R.Br.) Mett. . . . .	—	—	—	—	—	o	—
<i>penna-marina</i> (Poir.) Kuhn. . . . .	o	o	o	—	—	—	—
* <i>vulcania</i> (Blume.) . . . . .	—	—	—	r	—	—	—
<i>Chielanthus tenuifolia</i> (Burm.) Sw. . . . .	—	—	—	—	—	—	o
<i>Doodia caudata</i> (Cav.) R.Br. . . . .	—	r	r	—	—	—	—
<i>Doryopteris decomposita</i> (R.Br.) Kuntz. . . . .	—	—	—	vr	—	r	—
<i>Histopteris incisa</i> (Thunb.) Sm. . . . .	—	—	—	c	—	c	—
<i>Lindsaea linearis</i> Sw. . . . .	—	—	—	vr	vr	—	vr
* <i>Pellaea falcata</i> (R.Br.) Fée. . . . .	—	—	—	vr	—	—	—
<i>Pleopeltis diversifolia</i> (Willd.) Melvaine . . . . .	—	—	f	vc	—	vc	—
<i>Pleurosorus rutifolius</i> (R.Br.) Fée . . . . .	vr	r	r	o	—	o	—
<i>Polyposium Billardieri</i> (Willd.) C.Ch. . . . .	—	—	—	c	—	c	—
<i>gramitidis</i> R.Br. . . . .	—	—	—	r	—	o	—
<i>Pteridium aquilinum</i> (L.) Kuhn. . . . .	—	—	lc	—	—	—	lc
* <i>Pteris comans</i> Forst. . . . .	—	—	—	—	—	—	—
* <i>tremula</i> R.Br. . . . .	—	—	—	—	—	—	—
<i>Polystichum aculeatum</i> (L.) Schott. . . . .	o	o	o	c	—	c	—
<i>adiantiforme</i> Schott. . . . .	—	—	—	r	—	f	—

## PLATE XIV

Figures 2, 3, and 4 are copyright by Mr. J. J. N. Barnett, Hobart, and are reproduced here with his kind permission.

FIG. 1.—General view of Mt. Wellington looking west.

FIG. 2.—Aerial view of north side of mountain under snow showing the open character of the *E. coccifera* and *E. coccifera-urnigera* associations above compared with the denser *E. obliqua-regnans* below. (Photog. J. J. N. Barnett.)

FIG. 3.—Aerial view of summit of Mt. Wellington showing shrubberies of Austral-Montane Formation and the rocky nature of the ground. (Photog. J. J. N. Barnett.)

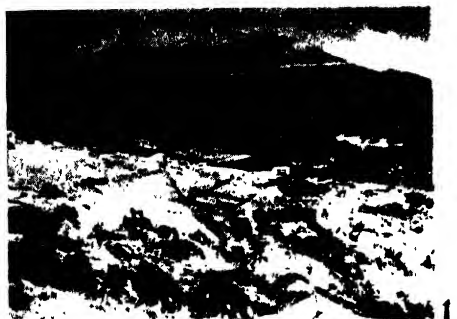
FIG. 4.—Aerial view of top of Mt. Wellington plateau under light snow showing the distribution of the *E. coccifera* consociation (dark) on the better drained portions, and the Austral-Montane (snow covered) on the flatter portions. The dark isolated patch in the upper right hand quarter is the "nunatak" Dead Island. (Photog. J. J. N. Barnett.)

FIG. 5.—*E. coccifera* consociation, general appearance showing the very rocky ground.

FIG. 6.—*E. coccifera* consociation wetter phase showing *Nothofagus Cunninghamhami* as a tall shrub.

FIG. 7.—*E. coccifera* as a shrub 3 feet high towards the edge of the plateau.

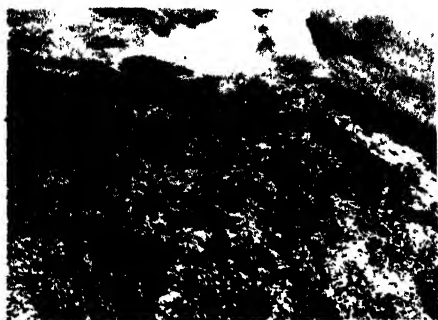
FIG. 8.—*Poa caespitosa* grassland with scattered *Oxothamnus ledifolius*.



1



2



3



4



5



6



7



8

# PLATE XV

- FIG. 1.—General view of the swamp community with the "nunatak" Dead Island in the background.
- FIG. 2.—Swamp-shrubbery ecotone showing *Baccharis Gunniana*, *Astelia alpina* and *Ozothamnus ledifolius* (shrub).
- FIG. 3.—Swamp-*E. coccifera* ecotone, *Astelia alpina*, *Poa caespitosa* and *Richia procea* in foreground.
- FIG. 4.—Area of swamp-community within *E. coccifera* consociation. Mixture of *Baccharis Gunniana* and *Glechoma dicarpa* in the foreground.
- FIG. 5.—*Abrotanella Fosteriodes* invaded by herb species.
- FIG. 6.—*Abrotanella Fosteriodes*, old plant in swamp-grassland ecotone nearly completely covered. The shrub in the centre is *Richia Gunn.*
- FIG. 7.—Old *E. coccifera* tree (relict) with *E. urnigera* saplings.
- FIG. 8.—*Leptospermum rupestre*, in shrub community near the summit.



1.



2.



3.



4.



5.



6.



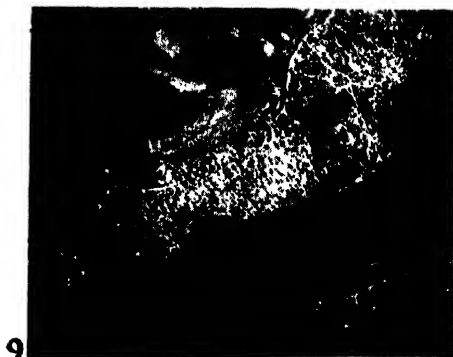
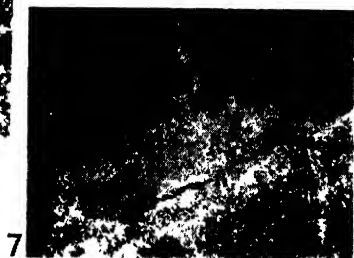
7.



8.

# PLATE XVI

- FIG. 1.—*E. obliqua-regnans* association, *E. obliqua* society. Shrub layer denuded by repeated fires.
- FIG. 2.—*E. obliqua-regnans* association, *E. regnans* society, showing tall shrub layer of *Pomaderris apetala* and *Olearia argophylla*, etc.
- FIG. 3.—“Gully community” in *E. obliqua-regnans* association (in background). Lower altitude type.
- FIG. 4.—Interior of “gully community” higher altitude type. The tree on the left is *Nothofagus Cunninghamii* while *Atherosperma moschata* leaves may be seen on the extreme right of the picture. *Dicksonia antarctica* in the foreground.
- FIG. 5.—*E. coccoloba-urnigera* association showing *E. urnigera*, *Olearia stellulata* in the foreground *Richea dracophylla* in middle distance and *E. urnigera* sapling sociies in the background.
- FIG. 6. Interior of “gully community” in Fig. 3. above showing stems of *Olearia argophylla* and ferns (*Pleopeltis diversifolia*) and *Blachnum* sp. in foreground.
- FIG. 7.—Aerial view of Snake Plains. Upper left hand corner regenerating *E. urnigera* and *E. Johnstoni* on dolerite talus covering the sandstone of the Plains; lower right hand corner *E. obliqua-regnans* forest on intrusive dolerite mass. Observe the sharply defined ecotone between the swamp and forest vegetation, also the white tops of the dead trees rising above the regenerating forest.
- FIG. 8.—*E. obliqua-regnans* association showing *E. obliqua* and tall shrub layer.
- FIG. 9.—Aerial photograph of lower ridges showing the marked contrast between the open forest of the N.W. side of the ridge and *E. globulus* community on the sheltered side.





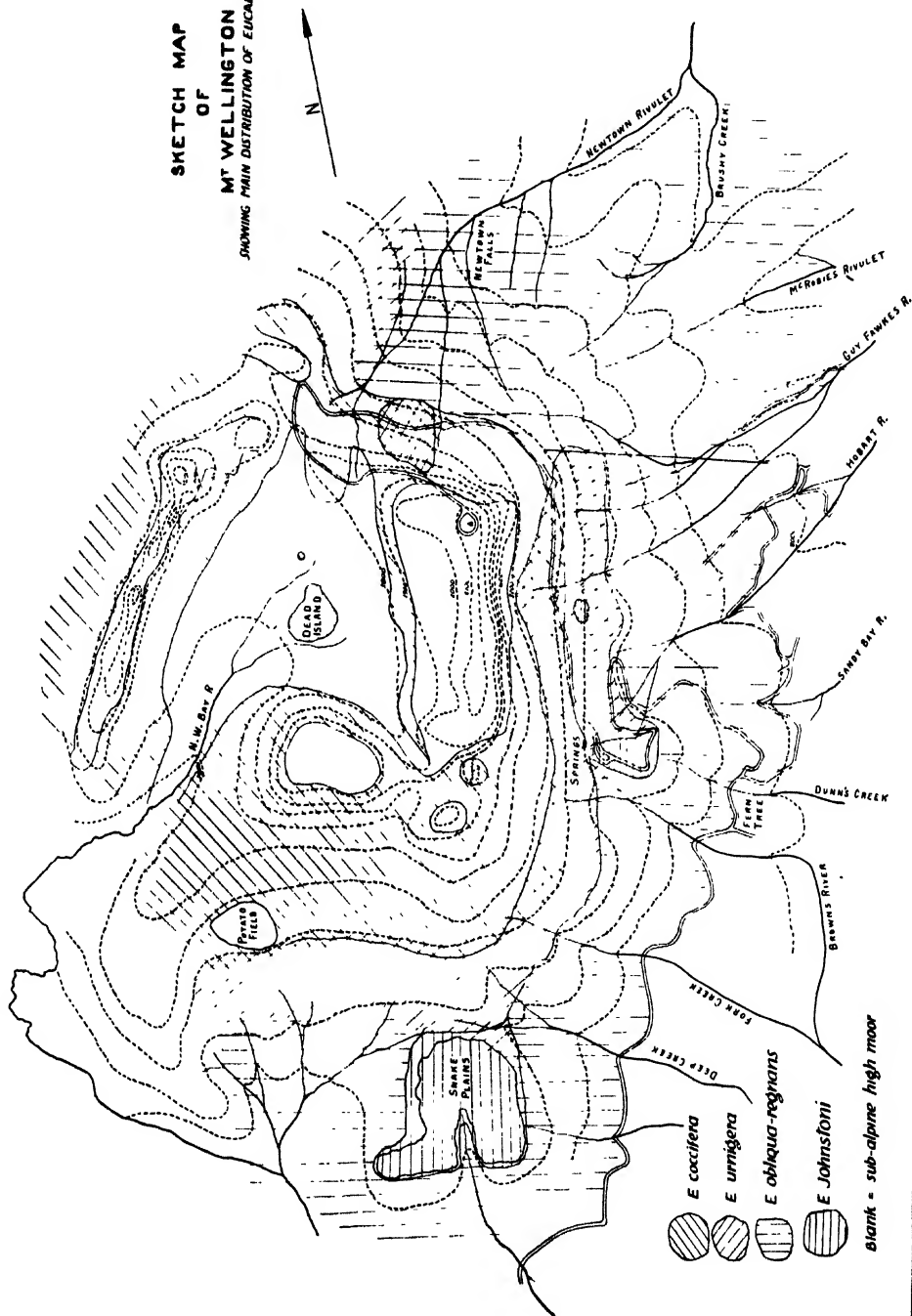
**Sketch map of Mt. Wellington, showing main distribution of Eucalypts.**

**Scale: 1 mile = 1½ inches [approx ]**

# SKETCH MAP OF

## MT WELLINGTON

SHOWING MAIN DISTRIBUTION OF EUCALYPTS





## The Toxopidae, a new Family of Spiders

By

V. V. HICKMAN, D.Sc.

(Read 13th Nov., 1939)

PLATES XVII, XVIII, XIX

The present paper is a contribution to the work of the Tasmanian Biological Survey, and deals with a new spider, *Toxops montanus*, from the summit of Mt. Wellington. The characters of the spider seem to justify the establishment of a new family, for which the name Toxopidae is suggested.

Order ARANEAE

Sub-order DIPNEUMONOMORPHAE

Branch TRIONYCHAE

TOXOPIDAE, fam. nov.

Cribellum and calamistrum lacking. Colulus present. Six spinnerets, anterior pair larger than the others. Chelicerae with a scopula and lateral condyle. Both margins toothed. Labium free. Maxillae slightly converging and furnished with a scopula. Legs laterigrade and without scopulae. Trochanters not notched. A distinct pretarsus present. Three tarsal claws. Upper claws pectinate in a single row, similar in male, dissimilar in female. A tarsal pulvillus consisting of a pair of large tenent hairs present. Spurious claws wanting. Trichobothria in two rows on tibiae, in one on metatarsi and in an irregular row on tarsi. Integument with barbed hairs. Eight eyes, which, when viewed from above, form a recurved row. Posterior lateral eyes very large. One pair of book-lungs in normal position. A single tracheal spiracle close to spinnerets. Tracheal system extending into the cephalothorax and its appendages. Pedipalp of female with a straight non-pectinate claw.

*Toxops*, gen. nov.

Carapace as in *Xysticus*. Eight eyes in a recurved row. PLE very large. PME minute and in front of PLE. Clypeus narrow. Furrow of chelicerae oblique, promargin with one conical tooth and a bicuspid tooth, retromargin with three teeth. Labium wider than long, reaching slightly beyond middle of maxillae. Sternum shield-shaped, as wide as long. Legs 4.2.3.1. in male. Spines on femora, tibiae and metatarsi, but none on tarsi.

Genotype.—*Toxops montanus*, sp. nov.

*Toxops montanus*, sp. nov.

(Plates XVII, XVIII, XIX)

## Male.—Measurements in millimetres:—

Total length	2.78
Length of cephalothorax	1.22
Width of cephalothorax	1.16
Length of abdomen	1.56
Width of abdomen	1.04

<i>Leg</i>	<i>Femur</i>	<i>Patella</i>	<i>Tibia</i>	<i>Metatarsus</i>	<i>Tarsus</i>	<i>Total</i>
1	1.10	0.46	0.87	0.75	0.52	3.70
2	1.27	0.46	0.98	0.81	0.52	4.04
3	1.22	0.46	0.93	0.81	0.52	3.94
4	1.22	0.46	0.98	0.93	0.52	4.11

*Colour*.—Carapace light brown with black lateral margins and a wide dark brown band on each side, extending from PLE to the posterior margin. Legs, palpi, chelicerae, sternum and maxillae light brown. Labium dark brown. Dorsal surface of abdomen brown with a median longitudinal dark-brown mark anteriorly, followed by three or four pairs of dark brown spots, which tend to form chevrons towards posterior end.

*Carapace*.—Nearly as wide as long. Head part flat. The thoracic groove longitudinal, its front end being on a level with the posterior margin of the PLE. Posterior declivity steep and much shorter than the flat portion of the carapace. There is a slender bristle on each side of the thoracic groove. The flat part of carapace is lightly clothed with white barbed hairs, while at the sides, in front and on the lateral margins, are a few black setae. The form of the carapace resembles that of the female (Pl. XVIII, figs. 5 and 6).

*Eyes*.—Viewed from above the eight eyes form a recurved row (Pl. XVIII, fig. 5). The PLE are very large and mounted on conspicuous black tubercles. The PME are minute and in front of the PLE. The eye ratio AME:ALE:PME:PLE = 12:15:7.5:24. The AME are separated from each other by about 16/12 of their diameter; from ALE by 14/12 of their diameter. The ALE are separated from PME by a space equal to 9/12 of the diameter of AME. The PLE are separated from ALE and from PME by a space equal to 18/12 of the diameter of AME. Viewed from in front the ALE are at a higher level than the AME (Pl. XVIII, fig. 7). The clypeus is 15/12 of the diameter of AME.

*Chelicerae*.—Conical, 0.46 mm. long. Clothed in front with a few hairs. A small lateral condyle is present. Furrow oblique. Promargin armed with a small conical tooth and a large bicuspid tooth (Pl. XVIII, fig. 13). Retromargin armed with three teeth, that nearest the base of fang being the largest. A scopula consisting of 5 or 6 barbed hairs is present on the promargin and a very long barbed hair on each side near base of fang.

*Maxillae*.—Slightly converging, 0.35 mm. long. Outer angle rounded. Serrula long, reaching outer angle. Scopula as shown in Pl. XIX, fig. 17.

*Labium*.—Wider than long in ratio 3:2. Apex truncate, reaching slightly beyond the middle of maxillae.

*Sternum*.—Shield-shape, slightly convex, as wide as long, ending in a point, which separates the fourth coxae. Lightly clothed with black hairs (Pl. XIX, fig. 17).

**Legs.**—4.2.3.1. Coxae cylindrical. The podomeres are clothed with barbed hairs. About eight trichobothria arranged in two rows on each tibia, three in a single row on each metatarsus, and three in an irregular row on each tarsus. The trichobothria increase in length towards the apex of the segment. Each leg has a distinct pretarsus carrying three tarsal claws. The superior claws are pectinate, the inferior claw smooth. In the first pair of legs the pro-claw has six blunt teeth, the retro-claw six blunt teeth and one small sharp tooth near the base (Pl. XVIII, fig. 11). In the other legs the claws are similar but with only five teeth. A scopula is lacking. Claw-tufts, however, are represented by a pair of large club-shaped tenent hairs. These tenent hairs form a kind of pulvillus, resembling that in *Apostenus fuscus* Westr. (Simon 1897, p. 137, fig. 145). Except for a difference in the pectination of the claws, the pretarsus of the male resembles that of the female (Pl. XVIII, fig. 8).

**Palpi.**—The form of the right palpus is shown in Pl. XVIII, figs. 9 and 10. The podomeres have the following lengths in mm:—Femur 0.406, patella 0.232, tibia 0.30, tarsus 0.64. The copulatory apparatus consists of a flat sickle-shaped translucent conductor, which, extending beyond the margin of the tarsus, curves round the apex and prolateral side. The tip rests against the ventral surface of the tibia. The embolus makes one complete turn in an opposite direction to that of the conductor. On the dorsal side the tarsus is furnished with a large basal excavation, within which the surface is finely granulate. The tibia is broad and somewhat dorso-ventrally compressed. On its dorsal surface near the apex is a large curved apophysis, which projects into the excavation on the tarsus. Two other apophyses are present on the retro-lateral side of the tibia near the apex. Three trichobothria are arranged in a triangular group on the dorsal surface of the tibia.

**Spines.**—*First leg.*—Femur: dorsal 1-1, prolateral 1, elsewhere 0. Patella: dorsal 1-1, elsewhere 0. Tibia: dorsal 1-1, prolateral 1, retrolateral 1, ventral 2-2-0. Metatarsus: dorsal 1, prolateral 0, retrolateral 0, ventral 2-2-2. Tarsus 0. *Second leg.*—Femur: dorsal 1-1, prolateral 1, elsewhere 0. Patella: dorsal 1-1, elsewhere 0. Tibia: dorsal 1-1, prolateral 0, retrolateral 1, ventral 2-2-0. Metatarsus: dorsal 1, prolateral 0, retrolateral 0, ventral 2-2-2. Tarsus 0. *Third leg.*—Femur: dorsal 1-1, elsewhere 0. Patella: dorsal 1-1, elsewhere 0. Tibia: dorsal 1-1, prolateral 0, retrolateral 1, ventral 2-2-0. Metatarsus: dorsal 1, prolateral 0, retrolateral 0, ventral 2-2-2. Tarsus 0. *Fourth leg.*—Femur: dorsal 1-1, elsewhere 0. Patella: dorsal 1-1, elsewhere 0. Tibia: dorsal 1-1, prolateral 0, retrolateral 1, ventral 2-2-1. Metatarsus: dorsal 1, prolateral 0, retrolateral 0, ventral 2-2-2. Tarsus 0.

**Abdomen.**—Oval, clothed with recumbent barbed hairs and fine erect bristles. Six spinnerets. The anterior pair are short truncated cones, two-jointed, but the apical joint is very small and difficult to see, except in microscopic preparations. The other spinnerets are much smaller than the anterior pair, and in ventral view are hidden by the latter. There is a small colulus immediately in front of the anterior spinnerets.

**Female.**—Measurements in millimetres:—

Total length	2.90					
Length of cephalothorax	1.22					
Width of cephalothorax	1.16					
Length of abdomen	1.74					
Width of abdomen	1.27					
<i>Leg</i>	<i>Femur</i>	<i>Patella</i>	<i>Tibia</i>	<i>Metatarsus</i>	<i>Tarsus</i>	<i>Total</i>
1	0.94	0.48	0.68	0.63	0.44	3.17
2	1.08	0.52	0.75	0.65	0.44	3.44
3	1.01	0.45	0.71	0.63	0.44	3.24
4	0.93	0.38	0.70	0.65	0.44	3.10

The female (Pl. XVII, fig. 1) resembles the male in coloration and general appearance. Hence only the following characters need be described:—

*Eyes*.—The eight eyes are arranged as shown in Pl. XVIII, figs. 5, 6 and 7. The eye-ratio AME: ALE: PME: PLE = 5:8:2:14. The AME are separated from each other by twice their diameter and from ALE by  $7/5$  of their diameter. The ALE are separated from PME by a space equal to  $6/5$  of the diameter of AME. The PLE are separated from ALE by twice the diameter of AME and by slightly less than this distance from PME.

*Legs*.—These are much shorter than those of the male, and the order of the relative lengths is different, being 2.3.1.4. The tarsi end in a pretarsus carrying three claws and a pulvillus (Pl. XVIII, fig. 8). The inferior claw is shorter and blunter than in the male. The superior claws are markedly dissimilar. The pro-claw has ten well-developed teeth, which gradually increase in size towards the apex of the claw. The retro-claw has only one well developed tooth, the others being vestigial (Pl. XVIII, fig. 12).

Trichobothria and spines are arranged as in the male.

*Palpi*.—The segments have the following lengths in mm:—Femur 0.38, patella 0.22, tibia 0.33, tarsus 0.38. The tarsal claw is straight and smooth. There are five trichobothria on the dorsal side of the tibia, arranged in a prolateral row of 2 and a retrolateral row of 3. None on tarsus. Spines are arranged as follows:—Femur: dorsal 1-1, elsewhere 0. Tibia: dorsal 1-1, prolateral 2-2, retrolateral 1-1, ventral 0. Tarsus: dorsal 1-1, prolateral 2-2-2, retrolateral 2-2-2, ventral 0.

*Epigynum*.—The form of the epigynum as seen in transparent preparations is shown in Pl. XIX, fig. 14. The spermatheca of each side is a strongly convoluted tube. The convolutions are close to the ventral surface and in most specimens are visible through the integument. The inner surface of the posterior coils is furnished with a number of conical projections.

*Locality*.—Mount Wellington, Tasmania. 31st May, 1939.

### Respiratory System

The respiratory system was studied both in serial sections and in specimens treated with caustic potash solution. One pair of book-lungs is present in the normal position in front of the epigastric furrow. In the adult female each book-lung has 17 leaves.

The tracheal spiracle in front of the spinnerets leads into a shallow atrium. From this two stout trunks pass directly forward below the ventral longitudinal muscles. Just beyond the epigastric furrow each trunk gives rise to a large number of fine tubules which pass through the petiolus into the cephalothorax. In a transverse section through the petiolus of one specimen, nearly two hundred of these tubules could be counted (Pl. XIX, fig. 15). Each leg receives about six tubules. The other tubules penetrate to all parts of the cephalothorax.

The abdomen is supplied with tracheae given off from the sides of the two main trunks. These are well shown in a whole mount of the tracheal system removed from the last exuvium of a specimen which underwent ecdysis in captivity (Plate XVII, fig. 4).

### The Heart

No attempt was made to study the circulatory system in detail. The heart, however, was examined in serial sections and also dissected from the abdomen and examined whole. It has three pairs of ostia.

### The Thoracenteron

The thoracenteron gives rise to three pairs of lateral caeca, which extend laterally and ventrally ending near the coxae of the second, third and fourth pairs of legs respectively (Pl. XIX, fig. 16). In addition to the lateral caeca there is a median bilobed caecum arising near the junction of the thoracenteron with the sucking stomach and extending forward above the latter.

### Habits, Egg-sac and Courtship

*Toxops montanus* is found on low shrubs, especially the Grass-tree, *Richea scoparia* Hooker, growing on the summit of Mount Wellington. The spider does not spin a web. It runs very quickly and its laterigrade legs enable it to creep between the closely arranged leaves of the Grass-tree. During May, 1939, several mature females, together with immature specimens of both sexes, were collected. These were placed in a small vivarium in the laboratory and provided with small branches from the shrubs on which they were found. The spiders require fairly moist conditions, and it was necessary frequently to sprinkle the vivarium with water.

About the 16th July, 1939, one of the mature females made an egg-sac, which was oval in outline and measured 3.54 mm. long by 2.32 mm. wide. It was closely applied to the upper surface of a leaf of the Grass-tree and was made of pure white silk. The egg-sac was covered with leaf fragments and other debris (Pl. XVII, fig. 3). After about four weeks the sac was opened and found to contain two eggs in process of development. Each egg measured 0.93 mm. long by 0.75 mm. wide. They were not disturbed but allowed to remain in the egg-sac until they hatched. This occurred on 17th September, 1939. The newly-hatched spider underwent its first ecdysis on 6th October, 1939.

Some of the immature males and immature females collected on Mount Wellington were kept until they reached maturity, the two sexes being placed in separate vivaria. A male underwent its final ecdysis on the 17th July, 1939, and a female on the 10th August, 1939. These two spiders were placed together in a glass specimen tube on the 20th August, 1939. The male soon gave signs of sexual excitement and was observed to rub the tarsi of the first pair of legs against the side of the tube. Apart from this, however, there seemed to be very few indications of a preliminary courtship. After repeating the movements of the tarsi several times, the male rushed at the female and copulation occurred. This took place at 1.20 p.m., the spiders adopting the position shown in Pl. XIX, fig. 18. The female remained in a more or less passive state during the whole process, which lasted for more than an hour. Its completion, however, was not observed.

At 7.10 p.m. the male was removed from the tube and another male admitted. Copulation with the latter occurred at 7.20 p.m. and lasted for more than five hours, the spiders being kept under observation until 12.20 a.m. on 21st August, 1939. The male palpi were not employed simultaneously, the left palpus being applied first and then the right.

The female was removed next morning and kept alive in a separate vivarium until 4th November, when she made her first egg-sac. It follows from the above observations that spermatozoa may be stored in the spermatheca of the female for at least 74 days before eggs are laid.

### SYSTEMATIC POSITION OF *TOXOPS MONTANUS*

*Toxops montanus* shows many features possessed by the Agalenidae, but it differs from members of this family in the arrangement of the eyes, the pectination



of the tarsal claws, the presence of a distinct pretarsus and pulvillus and in the tracheal system extending into the cephalothorax.

In being a dipneumone spider having the tracheal spiracle close to the spinnerets and the tracheal system penetrating the cephalothorax, *Toxops montanus* resembles the families Uloboridae, Dictynidae, Micryphantidae, Prodidomidae and Attidae and also the genus *Zodarion*. In other respects it differs widely from these groups,

The arrangement of the eyes approaches that of the Selenopidae.

The peculiar tarsal pulvillus recalls the similar structure in *Apostenus fuscus* Westr., but the latter spider is one of the Clubionidae and has only two tarsal claws. These, however, like the upper claws of the female of *T. montanus*, are dissimilar.

*T. montanus* thus possesses characters found in several widely separated families. For these reasons the establishment of the new family, Toxopidae, seems necessary.

The above research was carried out in the Biology Department of the University of Tasmania and under the auspices of the Trustees of the Ralston Bequest.

#### REFERENCES

- PETRUNKEVITCH, A., 1938.—*Trans. Conn. Acad.* 31, p. 338.  
———, 1939.—*Trans. Conn. Acad.* 33, p. 155.  
SIMON, E., 1897.—*Hist. Nat. des Araignées*, 2, p. 137.

#### PLATE XVII

*Toxops montanus*, sp. nov.

FIG. 1.—Photograph of female, X 7.

FIG. 2.—Photograph of male, X 7.

FIG. 3.—Photograph of egg-sac on leaf of *Richea scoparia*, X 7.

FIG. 4.—Microphotograph of tracheal tubes removed from the exuvium of the penultimate instar, X 47.



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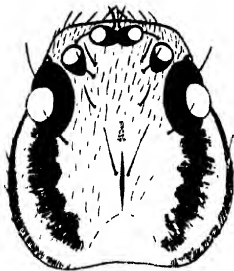


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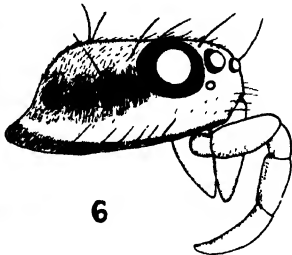
PLATE XVIII

*Torops montanus*, sp. nov.

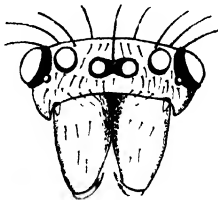
- FIG. 5.—Dorsal view of carapace and eyes, ♀.  
FIG. 6.—Lateral view of carapace and eyes, ♀.  
FIG. 7.—Front view of face and chelicerae, ♀.  
FIG. 8.—End of tarsus showing pretarsus, claws and the two large tenent hairs forming a pulvillus, ♀.  
FIG. 9.—Ventral view of right palpus, ♂.  
FIG. 10.—Dorsal view of right palpus, ♂.  
FIG. 11.—Pectination of tarsal claws, ♂.  
FIG. 12.—Pectination of tarsal claws, ♀.  
FIG. 13.—Retrolateral view of left chelicera showing bicuspid tooth on promargin, ♂.



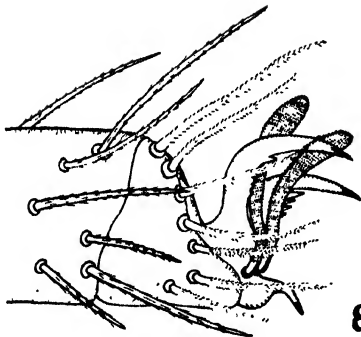
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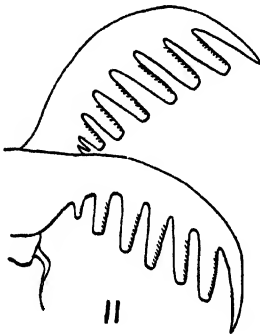
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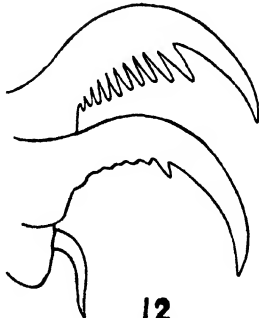
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PLATE XIX

*Toxops montanus*, sp. nov.

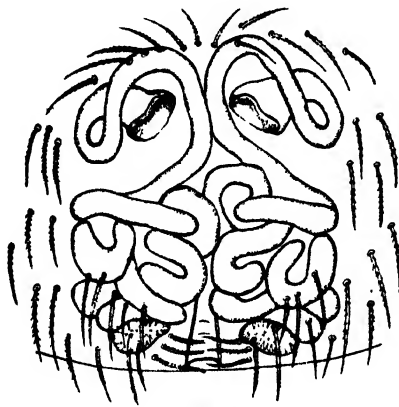
FIG. 14.—Ventral view of epigynum as seen in transparent preparations.

FIG. 15.—Transverse section through petiolus showing the large number of tracheal tubules below the gut. ♀.

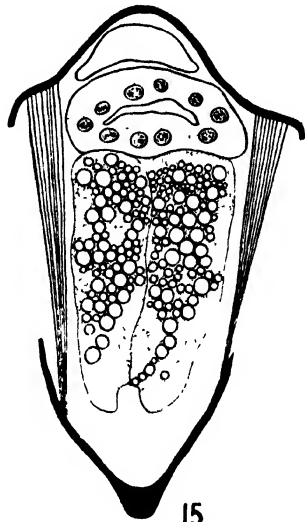
FIG. 16.—Dorsal view of thoracenteron *in situ*, ♀.

FIG. 17.—Sternum, labium and maxillae, ♂.

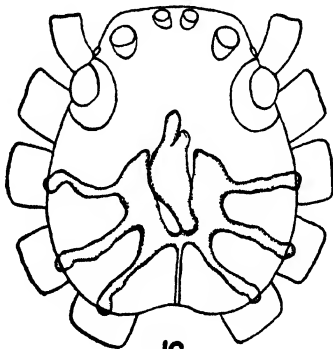
FIG. 18.—Position adopted by male and female in copulation.



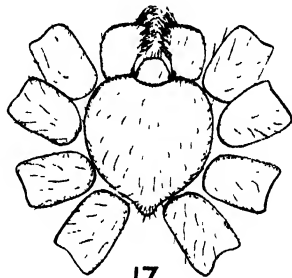
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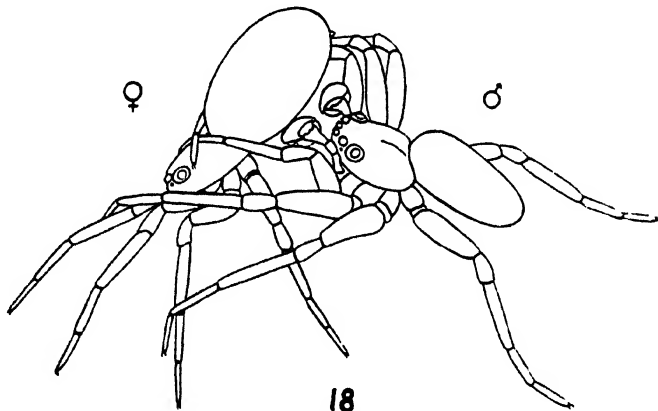
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# The Royal Society of Tasmania

1939

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**Patron:**

His Majesty the King.

**President:**

His Excellency Sir Ernest Clark, K.C.B., K.C.M.G., C.B.E.

**Vice-Presidents:**

W. L. Crowther, D.S.O., M.B., V.D., 1939.

W. H. Clemes, B.A., B.Sc., 1939, 1940.

**Council:**

V. V. Hickman, B.A., D.Sc., 1939, 1940, 1941.

A. N. Lewis, M.C., LL.D., M.H.A., 1939, 1940, 1941.

E. E. Unwin, M.Sc., 1939, 1940.

H. Allport, LL.B., 1939, 1940.

J. W. Evans, M.A. (Cantab.), F.R.E.S., 1939.

W. H. Hudspeth, B.A., 1939.

**Standing Committee:**

W. L. Crowther, A. N. Lewis, V. V. Hickman, J. Pearson.

**Hon. Treasurer:**

S. Angel.

**Hon. Editor.**

Joseph Pearson, D.Sc. (Manc.), D.Sc. (Liverpool), F.R.S.E., F.L.S.

**Auditor:**

Walter E. Taylor, F.F.I.A., F.I.A.S.

**Secretary and Librarian:**

Joseph Pearson, D.Sc., F.R.S.E., F.L.S.



## Annual Report

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The Annual Meeting was held in the Society's Room, Tasmanian Museum and Art Gallery, Hobart, on the 16th February, 1939.

The following Office-bearers were elected:—

Under the Society's Rules Dr. A. N. Lewis retired from the office of Vice-President, and Mr. W. H. Clemes was appointed in his place (retiring 1941).

Treasurer: Mr. S. Angel.

Under the Rules Mr. W. H. Clemes and Professor A. L. McAulay retired from the Council, and the following members of Council were elected in their place:—

Dr. A. N. Lewis (retiring 1942).

Dr. V. V. Hickman (retiring 1942).

The Council made the following appointments at its first meeting:—

Secretary and Librarian: Dr. Joseph Pearson.

Assistant Librarian: Mrs. Clive Lord.

Standing Committee: Dr. W. L. Crowther, Dr. A. N. Lewis, Mr. W. H. Hudspeth, and the Secretary.

The Council elected the following five Trustees to serve on the Board of Trustees of the Tasmanian Museum and Art Gallery and the Botanical Gardens:—Mr. W. H. Hudspeth, Mr. W. H. Clemes, Dr. A. N. Lewis, Dr. W. L. Crowther, Mr. J. W. Evans.

Eleven meetings were held during the year (see proceedings for abstract of papers). In addition scientific papers were submitted for publication and have been printed in the present volume.

During 1939 the Tasmanian Museum and Botanical Gardens Act was amended by Parliament so as to alter the representation of the Government and the Royal Society on the Board of Trustees. Previously the Board was composed of nine members as follows:—

Trustees appointed by the Government	2
Trustees appointed by the City Council	2
Trustees appointed by the Royal Society of Tasmania	5

Under the amended Act the representation will be as follows:—

Trustees appointed by the Government	5
Trustees appointed by the City Council	2
Trustees appointed by the Royal Society of Tasmania	2

This amendment will come into force in 1940.

### *Library*

During the year 382 volumes were added to the Library in addition to a number of reports and pamphlets from British and foreign countries. The number of Institutions on the Exchange List for the year was 283, being made up of 135 British, 52 American and 96 from other parts of the world. The Library now consists of 19,649 volumes.

The sum of £47 18s. 8d. was spent on books during the year, and the amount was allocated as follows:—

	£	s.	d.
General Fund	22	5	6
R. M. Johnston Fund	17	2	6
Morton Allport Memorial Fund	4	7	3
Beattie Memorial Fund	4	3	5

In addition the Tasmanian Museum spent £4 7s. 7d. on books and the Botanical Gardens £5 11s. 3d. These books have been placed in the Society's Library for safe-keeping, and are available to members.

358 book covers were provided during the year, making a total of 1608.

### *New Lantern*

During the year the Council decided to purchase a new lantern to replace the old one which was unsatisfactory, and an instrument has been obtained which serves three purposes, namely, an ordinary projection lantern with an epidiascope and microscopic attachment.

### *Membership*

The Society consists of the following members:—	1938.	1939.
Honorary Members	2	2
Corresponding Members	3	3
Life Members	7	7
Ordinary Members	232	240
Associate Members		3
Total	<hr/> 244 <hr/>	<hr/> 255 <hr/>

During the year 16 names were removed from the membership owing to deaths, resignations, etc., and 27 new names were added.

The Council regrets having to record the deaths of the following members during the year: Mrs. David Meredith, Hon. L. M. Shoobridge, Mr. L. Morrisby, Mr. F. E. Wallace, Mr. J. B. Scott.

### *Clive Lord Memorial*

At the General Meeting on 17th April the Clive Lord Memorial Prize of £10 was awarded to Mr. R. J. Linford for his essay on "The Customs Tariff and Economic Expansion—A Survey of the Industrial Development of Tasmania during the years 1803 to 1850 and its relation to revenue collections".

On 23rd October Professor J. B. Cleland of the University of Adelaide delivered the second Clive Lord Memorial Lecture on "Some Aspects of the Ecology of the Aboriginal Inhabitants of Tasmania and Southern Australia". His Excellency the Governor presented the Clive Lord Memorial Medal to Professor Cleland.

### *Printing of Papers and Proceedings*

Once again the Government has very generously printed the Papers and Proceedings. The Council wishes to record its appreciation of this generous assistance.

## Abstract of Proceedings

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16TH FEBRUARY, 1939

### *Annual Meeting*

The Annual Meeting was held in the Society's Room, Tasmanian Museum. The President, His Excellency the Governor, Sir Ernest Clark, K.C.B., K.C.M.G., C.B.E., presided.

The following were elected Office-bearers and members of the Council for 1939:—Vice-Presidents, Dr. W. L. Crowther (1 year), Mr. W. H. Clemes (2 years); Treasurer, Mr. S. Angel. Council: 3 years, Dr. A. N. Lewis and Dr. V. V. Hickman; 2 years, Mr. E. E. Unwin and Mr. Henry Allport; 1 year, Dr. J. W. Evans and Mr. W. H. Hudspeth.

Mr. Walter W. Taylor was appointed Hon. Auditor.

The following were elected members of the Society:—Dr. C. Craig, Dr. D. H. E. Lines, Mr. A. R. Bull, Mr. O. J. Sternberg, Alderman R. H. Lord.

Dr. F. W. Whitehouse gave an illustrated lecture on 'Experiences of a Geologist in the Field', of which the following is an abstract:—

Dr. Whitehouse explained that a palaeontologist's work was, briefly, the collection and study of fossils. The earth had been in existence about 2,000,000,000 years, and they could trace life back only 600,000,000 years. Before that period it was difficult to correlate things from country to country. This matter, however, was made comparatively easy by the existence of fossils, and it was his job as a palaeontologist to interpret fossils in that way. Persons had been working on those lines for a long while, and had built up an amazing number of facts.

In his main work of correlating the strata from place to place, the palaeontologist unearthed many curious creatures in a fossil state, and had revealed a great wealth of pre-existing floras and faunas, thus adding greatly to the knowledge of evolution. He illustrated this by examples, particularly as they applied to Australia, and to Tasmania. Some of the Tasmanian examples had been found very difficult of correlation with other zones in the world.

Dr. Whitehouse told of his practical experiences in the far west of Queensland, and in the Northern Territory, where he had spent the Summer vacations for the past seven years, and prior to that in the artesian basin of Australia. It was necessary for a palaeontologist to do his own collecting, and there were only four or five to cover the immense area of Australia. He concluded his lecture with a number of lantern slides.

20TH MARCH, 1939

A meeting was held in the Society's Room on this date. Mr. W. H. Hudspeth presided in the absence of the President.

Mr. Hudspeth announced the death of the Hon. L. M. Shoobridge, who had been a member of the Council for some years and mentioned the loss which Mr. Shoobridge would be to the community at large. The Council of the Society had already sent a message of condolence to Mrs. Shoobridge.

The following were elected members of the Society:—Ordinary Members, Mr. J. O. Henrick; Associate Members, Mrs. J. A. McElroy, Mr. R. W. Kerr.

It was announced that the Clive Lord Memorial Prize to the value of £10 had been awarded to Mr. R. J. Linford for his essay on 'The Customs Tariff and Economic Expansion—A Survey of the Industrial Development of Tasmania during the years 1803 to 1850 and its relation to revenue collections', and that the award would be made at the next meeting of the Society.

Dr. A. N. Lewis gave an illustrated lecture on 'Time Scales in recent Tasmanian Geological History', of which the following is an abstract:—

The advance in our knowledge of physiographical geology in the past 15 years has changed our ideas of Tasmanian geology.

At one time Tasmania was much more extensive than at present, was joined to the Mainland and consisted of flat or rolling plains like the Midlands to-day.

The first change was a considerable western uplift which spread along the northern coast to the north east giving a series of mountains at least 4000 feet higher than the original plain. Later these mountains were worn down so as to expose the ancient ore-bearing rocks.

This was followed by an ice age consisting of three phases. After the first glacial phase there was considerable volcanic activity giving large lava flows.

A second uplift caused the central, eastern and southern highlands. This uplift broke the old valleys frozen by the basalt lava flows and in places caused a difference in level of as much as 4000 feet in some valleys.

Next the Bass Strait was formed and considerable areas off the west, south and east coasts were submerged.

All these movements were the result of pressure caused by the sinking of the ocean floor and the consequential squeezing of the southern part of the Australian land mass. The mountains were compensational effects of that pressure. Thus the scenery and geographical features of Tasmania have been produced in relatively recent times. The movements were gradual and are probably still in progress.

17TH APRIL, 1939

A meeting was held in the Society's Room on this date, the President, His Excellency the Governor, presiding.

Mr. Henry Allport was elected to the Council in place of the late Hon. L. M. Shoobridge.

The following were elected members of the Society:—Mr. L. Cerutti, Mr. G. C. Israel.

The Clive Lord Memorial Prize was presented to Mr. R. J. Linford.

Short illustrated notes on biological subjects were given as follows:—

Professor A. L. McAulay gave a paper on 'Saltants of a fungus produced by ultra-violet rays', illustrated by lantern slides.

Dr. V. V. Hickman showed a specimen of the Pouched Lamprey, *Geotria australis* Gray, which occurs in Australia, New Zealand and South America.

A specimen from Tasmania was described under the name *Geotria allporti* by Gunther in 1871. F. G. Maskell (*Trans. Proc. N.Z. Inst.*, Vol. 60, 1929) has shown that, after hatching, *Geotria australis* passes through four well marked stages in its development, namely, the Ammocoetes stage, the Macrophthalmia stage, the Velasia stage and finally the adult or sexually mature stage. These developmental forms are so different that for a number of years they were regarded as distinct species. The large gular pouch is well developed only in the male, the female often showing no signs of a pouch. The Velasia stage is spent at sea and there is some evidence that, on returning, the lamprey enters Tasmanian rivers in May or June.

Dr. H. D. Gordon exhibited several specimens of the 'Native Bread'—*Polyporus mylittae*.

Dr. Gordon exhibited several specimens of the 'Native Bread'—*Polyporus mylittae*, including one which he had recently received from Dr. R. A. Scott of the Department of Agriculture, Launceston, and which showed an unusually prolific growth of the mushroom-like reproductive structures or sporophores. He explained that the so-called 'bread' was a sclerotium, a dense mass of fungus tissue in which food material is stored, to be used up later as the sporophores develop. This habit could be compared with that of many flowering plants which store food in a bulb or tuber and use it up later in the rapid development of leaves and flowers.

Dr. Gordon also exhibited a specimen of a moth caterpillar parasitised by the fungus *Cordyceps*, and explained that in this case the fungus assimilated all the internal tissues of the caterpillar, which were replaced by dense fungus tissue, the outer layers alone persisting unchanged. thus a sclerotium was formed retaining the appearance of the caterpillar, and from this sclerotium the visible spore-bearing part of the fungus developed.

Mr. R. G. Brett discussed the identification of Eucalypts in the Field.

He pointed out that the difficulties in identification of Eucalypts in the field arise from a failure to recognize the nature of an average Eucalypt population. In general the following components are present:—

- (a) Species exhibiting marked variability.
- (b) Interspecific hybrids and their segregating progeny.
- (c) Polymorphs.
- (d) Inter-polymorph-specific hybrids and their progeny.

The term polymorph was defined as a member of a population derived from two or more species but showing strongly the character of one, e.g., *xE. risdelata* derived from *E. risdoni* Hook., f. and allied species by hybridization. Polymorph populations exhibit varying degrees of fixation and in some cases approach that of a true species.

The types were illustrated from Tasmanian and Extra-Tasmanian collections in the form of photographs and seedling trees.

The question of a suitable terminology was discussed.

A short account of the principal insects that attack oak trees in Tasmania was given by Mr. J. W. Evans. The black deposit found so commonly on these trees is a secondary effect resulting from the growth of a sooty-mould fungus on the excreta of the oak-scale and the oak aphid. In conclusion the lecturer stated that, as the result of the activity of insect parasites of the scale and the aphid, the health of oak trees was steadily improving.

Dr. Pearson laid on the table an *Astraeid* coral, specimens of which had been found washed up on the northern shores of Tasmania. A specimen had also been found at Dover. The evidence pointed to the fact that this coral was living in Tasmanian waters, in itself a remarkable thing as *Astraeid* corals had not hitherto been found so far away from the tropics, so far as Dr. Pearson was aware.

8TH MAY, 1939

A meeting was held in the Society's Room on this date, the President, His Excellency the Governor, presiding.

Dr. Pearson brought to the notice of the Society the discovery in South African waters of a living *Coelacanthid* fish belonging to a group of *Crossopterygian* fishes which had hitherto been regarded as extinct.

The last recorded *Coelacanthid* fossil occurred in the Upper Cretaceous Age and so this discovery of a living member of the group was of the highest zoological interest and of supreme importance. Dr. Pearson recalled the discovery of the Tasmanian crustacean *Anaspides* in 1893, which bridged an even greater gap, as the relatives of this form had been regarded as having died out as early as carboniferous times. It was perhaps understandable that a relatively small animal such as *Anaspides* should have escaped the notice of observers for nearly a century after Tasmania was colonized by civilized men but it was amazing that a large living *Coelacanthid* fish should have evaded discovery.

Dr. J. W. Evans gave an account of Aquatic Insects.

Before dealing with the different groups of aquatic insects, mention was made of the pioneer workers who had investigated the life-history of a number of water insects. These were Reamur, Swammerdam, Lyonnet and de Geer. Structural adaptations that enable insects to live in water were discussed, especially those concerned with breathing, and in relation to the surface film. Examples of the principal groups of water-living insects were dealt with, and attention drawn to the wide range of conditions afforded by an aquatic medium. The lecture was illustrated by drawings and photographs and several live water insects exhibited.

5TH JUNE, 1939

A meeting was held in the Society's Room. His Excellency the Governor presided.

The following members were elected:—Ordinary, Professor E. R. Walker, Mr. H. J. Read; Associate, Mr. S. C. Morris.

Mrs. J. A. McElroy gave a paper on Dr. Joseph Milligan and some early records of the Royal Society of Tasmania.

This paper gave a brief biographical sketch, and an account of Dr. Milligan's activities as Secretary of the Royal Society from 1848 to 1860. It described many objects donated to the Museum when it occupied the premises at the corner of Harrington and Macquarie Streets, and also the development and products of the Botanical Gardens.

Mr. W. E. Masters gave a lecture on 'Free Immigration in the 1820's'.

#### 10TH JULY, 1939

A meeting was held in the Society's Room. In the absence of the President, Mr. W. H. Hudspeth presided.

The following members were elected:—Dr. A. B. Edwards, Mr. J. E. Cuthbertson.

Professor E. Ronald Walker gave a lecture on the economic background of the European situation. The lecture was illustrated by maps.

He pointed out that in studying the present situation in Europe we must recognise that leaders and parties can determine the course of events, only within certain limits imposed by economic conditions.

Behind the spectacular moves of politics certain fundamental economic pressures are operating which may prove to be more important in the long run than strokes of policy. For instance the population balance of Europe is changing. Of the expected increase of 100 million between 1930 and 1960, no less than 75 million will be in Eastern Europe and 15 million in Mediterranean countries. Central Europe will expand very slowly, while the populations of the West and North will stagnate. This shift in population complicates the relationships between rural and industrial Europe. In Eastern Europe there is chronic over-population of the rural areas, which used to be relieved by overseas emigration, but now can only be absorbed and supported by the industrialization of backward regions of Europe. The poverty of these Eastern countries prevents accumulation of the capital which is necessary for their industrialization. Consequently the future depends upon co-operation with the Western industrial powers which have capital available for investment. One obstacle to this co-operation is the desire of the industrial interests to preserve Eastern Europe as a market for Western manufactures and as a source of raw materials for Western industry.

Europe's problems cannot be solved by the piecemeal efforts of separate States, each insisting on its own sovereignty. Planning on a continental scale is needed. But European sentiment lags behind the facts of European economic unity. The Western democracies, Britain and France, have one foot in Europe and the other overseas; and Germany is obsessed by the delusion of racial supremacy. The other European powers are too small or too weak to play a dominant role in the reorganisation of Europe's economic life which is a necessary condition for the survival of European civilization.

Germany's leaders are bent on solving the European problem by dominating Central and Eastern Europe. Economically this implies the exploitation of the outlying states rather than their industrialization and does not promise a solution of their agrarian problems.

Both Germany and Italy back their diplomacy with the threat of a 'lightning war', but a war of attrition is more likely. In such a war the balance of economic strength would not be in Germany's favour.

#### 14TH AUGUST, 1939

A meeting was held in the Society's Room. In the absence of the President Mr. W. H. Hudspeth presided.

The following members were elected:—Mr. A. F. Ryan, Mr. G. K. Meldrum, Mr. W. S. Manson, Mr. G. H. Crawford, Mr. J. A. Dumaresq, Dr. B. A. Anderson, Mr. R. G. Hall, Miss G. M. F. Brown.

Dr F. P. Bowden gave a lecture on 'Polishing and the sliding of Ski' of which the following is an abstract:—

##### 1. *The Mechanism of Polishing*

The process of polishing is greatly influenced by the relative melting point of the polisher and the solid. The relative hardness is comparatively unimportant. Experiment shows that surface flow is brought about by an intense local heating of the surface irregularities to the

melting or softening point. The molten or softened solid flows or is smeared over the surface and very quickly solidifies to form the polished Beilby layer. These local high temperatures also play an important part in the wear and corrosion of sliding surfaces.

## 2. *The Sliding of Ski*

An experimental investigation is made of the experimental laws which govern the friction of solids sliding on ice and snow. The static friction is considerably higher than the kinetic friction. Within certain limits, the coefficient of kinetic friction is independent of the load, apparent area of contact and the speed of sliding. The kinetic friction on ice, at temperatures near the melting point, is very small but it increases as the temperature falls and at low temperatures reaches a value comparable with that observed on other crystalline solids. The friction is greatly influenced by the thermal conductivity of the sliding surface.

There is evidence that the low friction is due to the local formation of a thin water film at the points of sliding contact. The results suggest that, although pressure melting may play some part, the low friction observed for rapidly moving solids is due largely to melting by frictional heat.

Experiments with miniature and real ski on snow show that the same general laws are obeyed as on ice. The higher friction on snow is attributed to the extra work of displacing and compressing the snow crystals.

11TH SEPTEMBER, 1939

A meeting was held in the Society's Room. In the absence of the President Dr. W. L. Crowther presided.

The following members were elected:—Mr. A. Flach, Dr. W. P. Holman.

The subject of 'Inheritance of Visual Defects' was dealt with by Dr. J. Bruce Hamilton and Dr. J. Pearson.

Dr. Pearson explained the principles of genetics and the mechanism of heredity. The genes which are the unit factors of inheritance are discrete particles situated within the chromosomes. Each characteristic of an organism owes its presence to a particular gene or group of genes and it is not the characteristic which is inherited but the gene which produces the characteristic. Under normal conditions genes are handed on from parent to child unchanged.

Genes exist in homologous pairs or allelomorphs dealing with alternating or opposing characteristics. If each parent hands on to the child the same member of the allelomorphic pair the child will have a double dose (homozygous) of that particular gene. If, however, each parent hands on opposing allelomorphic genes the child will carry two unlike though homologous genes (heterozygous). The presence of one of these (the recessive gene) will be masked by the dominant gene and the child will bear outwardly the characteristic caused by the dominant gene only. In the case of human eye diseases, most of which are caused by recessive genes, if such recessive genes occur side by side with the dominant gene, the person will not be liable to the disease. If, however, each parent hands on to the child the recessive gene, the offspring will have a double dose of the recessive gene and will have the disease. Consanguineous marriages are not harmful in themselves but only because they make it possible for a double dose of disease-carrying recessive genes to be brought together in the children.

Dr. Pearson went on to show how the genes retain their individuality through succeeding generations and demonstrated the effects of different combinations of genes.

He then dealt with sex-linked inheritance. Many important eye diseases are sex-linked.

Dr. Hamilton followed and pointed out that hereditary defects of the eye fall into two categories, those causing blindness, and those causing sub-normal vision. One hundred and sixty pedigrees of inherited eye disease in Tasmania have been worked out by Hamilton, and these account for 19 of the known 46 inherited eye diseases. According to the researches of Counsell and Hamilton, 40 per cent of the blindness in Tasmania is due to inherited defects, namely, cataracts, Leber's optic atrophy, retinitis pigmentosa, detachment of the retina, glaucoma, and nystagmus. Those producing defective eyesight, without blindness are: microphthalmos, heratoconus, strabismus, senile macula degeneration, myopia, and astigmatism, so it is obvious that unless the problem of eugenics is faced by the Government, and the people of Tasmania, the cause of inherited eye defects and of blindness will be steadily maintained in this island. In the course of his lecture Dr. Hamilton illustrated his point by showing pedigrees of families carrying hereditary eye defects. These pedigrees were afterwards discussed by Dr. Pearson who explained their genetic significance. In conclusion Dr. Hamilton stated that a Sight Saving School had been opened in Hobart to deal with the education of children with defective sight, but the problem must sooner or later be attacked at its origin. A voluntary pre-marital advice clinic is urgently needed and voluntary sterilisation with safeguards should be made legal.

## 23RD OCTOBER, 1939

A meeting was held in the Society's Room. The President, His Excellency the Governor, presided.

The second Clive Lord Memorial Lecture was delivered by Professor J. B. Cleland, M.D., of the University of Adelaide. Before the lecture His Excellency the Governor presented the Clive Lord Memorial Medal to Professor Cleland.

Professor Cleland gave a lecture entitled 'Some Aspects of the Ecology of the Aboriginal Inhabitants of Tasmania and Southern Australia'. (See this volume, p. 1.)

## 26TH OCTOBER, 1939

A special meeting was held in the Society's Room. The President, His Excellency the Governor, presided.

Professor J. B. Cleland gave a lecture entitled 'Anthropological Expeditions in Central Australia' which was illustrated by cinema films.

## 13TH NOVEMBER, 1939

A meeting was held in the Society's Room. The President, His Excellency the Governor, presided.

The following papers were laid on the table and taken as read:—

T. Kobayashi: 'Lower Ordovician Fossils from Junee' (printed in full in the present volume, p. 61).

T. Kobayashi: 'Lower Ordovician Fossils from Caroline Creek' (printed in full in the present volume, p. 67).

A. N. Lewis: 'Geology of the Tyenna Valley' (printed in full in the present volume, p. 33).

A. N. Lewis: 'Record of Glossopteris from Cygnet' (printed in full in the present volume, p. 95).

J. Pearson: 'Notes on the Blood system of the Marsupialia' (printed in full in the present volume, p. 77).

V. V. Hickman: 'The Toxopidae, a new Family of Spiders' (printed in full in the present volume, p. 125).

N. J. B. Plomley: 'The Genus *Heterodoxus*' (printed in full in the present volume, p. 19).

G. B. Thompson: 'Distribution of *Heterodoxus*' (printed in full in the present volume, p. 27).

Mr. D. Martin gave an illustrated lecture on 'The Vegetation of Mount Wellington, Tasmania' (printed in full in the present volume, p. 97).

Mr. E. T. Emmett gave a short note on 'Tasmania's Oldest Road'.

Apart from tracks and rough minor roads Mr. Emmett claimed that the Hobart-New Norfolk road, which was completed in 1819, was the first road of importance to be constructed in Tasmania. It is interesting to recall that the real genesis of the road was bushranging. On 23rd October, 1814, a gang of robbers visited the home of Dennis McCarty at New Norfolk and made off with all the valuables they could carry. To recoup him his loss McCarty asked Governor Sorell, four years later, to give him a contract to build a good carriage road 16 feet wide from Hobart to New Norfolk, on consideration of being given:—2000 acres of land; 15 men on the store for 12 months at 1½ rations each; 8 bullocks and a cart; 500 gallons of rum, duty free; a tent for the men to sleep in and tools fit for the purpose. As there was some dispute as to whether the road should be from New Norfolk to New Town or New Norfolk to Hobart McCarty was recommended to undertake the whole road and leave the final terms to the judgment of the Governor in Chief.

In a letter dated 26th June, 1819, McCarty reported to Governor Sorell that the road was completed. A survey committee was appointed to inspect the road. They reported that the work had been done badly and that it would take 16 men four months to render the road passable. Governor Collins notified McCarty that the Government would complete the road, which would become a charge against his compensation.

It would appear that no final settlement of McCarty's compensation was made but McCarty received 500 acres of land at New Norfolk and 1000 acres at Dromedary. McCarty died early in 1820.



Mr. W. F. D. Butler exhibited a gold coin which recently came into his possession. This was a five Rupee gold coin of the East India Company, which was minted between the years 1822 and 1832.

Besides the English inscription 'English East India Company' it bears an inscription in Persian which interpreted reads 'Five Rupees of the Honourable East India Company'.

In 1803 Spanish dollars were stamped and circulated in Great Britain owing to the scarcity of local currency, and later on a shipment of Spanish dollars were obtained from Bengal and were made legal tender in this Colony. The Governor converted them into the well-known Holely dollar and Dump. Such coins passed currency in the Colony for a considerable time and helped the deficiency in currency. Many local merchants issued also their own tokens, mostly copper.

A committee of the Legislative Council was appointed to inquire into and report upon the expediency of introducing the Sicca rupee and the dollar of the United States into legal circulation of Van Diemen's Land, and such committee made a report on June 17th, 1835, which recommended that the Sicca rupee be made legal tender in Van Diemen's Land but not the dollar of the United States.

In consequence the Act 6 William IV No. 5, passed by the Legislative Council on the 2nd September, 1835, recites that 'there is at present a deficiency in the quantity of British silver money in actual circulation within this Colony, and it would therefore and for other reasons be of advantage to commerce to encourage the circulation of the rupee at or about its intrinsic value which as near as can be ascertained is 2s. or rather more'. It was therefore enacted 'that the Calcutta or Sicca rupee shall be a legal tender and be payable and received and taken in payment at or for the same sum or amount of 2s. and the said coin shall be payable and received accordingly at that rate in discharge and payment of all debts and sums whatsoever'.

Mr. Butler pointed out that this Act does not define the particular coin which was to be so taken but the wording apparently related to the silver Calcutta rupee of the East India Company. A gold coin of the value of five silver rupees would almost certainly be equally acceptable in the Colony and would easily circulate, and this coin can therefore be classed as one of the coins circulating in the Colony in or after the year 1835.

## Northern Branch

### Annual Report, 1939

All meetings of the 1939 Session, other than the Annual Meeting and Public Lecture, were held in the lecture room at the Queen Victoria Museum and Art Gallery. The schedule of ordinary meetings of previous years was extended, an extra meeting being held in October.

22ND MAY, 1939

#### *Annual Report and Public Lecture*

The Annual Meeting for 1939 was held in the classroom, Public Library, on this date, at 7.30 p.m.

The Hon. Tasman Shields presided. The following were elected officers for 1939:—  
President: Mr. F. Smithies.

Council: Mr. F. Smithies (Chairman), Mr. F. Heyward, Hon. Tasman Shields,  
Mr. W. R. Rolph, Mr. R. S. Padman, Mr. J. R. Forward, Mr. D. V. Allen,  
Mr. J. E. Heritage, Dr. R. A. Scott

Hon Secretary: E. O. G. Scott.

Hon. Auditor: R. S. Padman.

The statement of accounts, which showed a credit balance of £24 1s. 9d., was read and adopted.

The Annual Meeting was followed, at 8 p.m., by a public lecture, 'Colour Photography in Tasmania' by Mr. H. J. King. The lecture was given in the Main Hall, Public Library, the accommodation of which was taxed by an audience estimated to number 350. An abstract of the lecture is subjoined.

Mr. King gave a short introductory talk on colour photography, in the course of which he discussed the several methods adopted in attacking the problem, and reviewed recent developments that have made the taking of satisfactory pictures in colour a successful commercial proposition.

The speaker then presented a remarkably fine series of coloured moving-pictures prepared by himself. Subjects dealt with covered a wide field, including pictorial characteristics of the seasons; Tasmanian scenery, particularly in the Cradle Mountain Reserve; life on the seashore; trout fishing in Tasmania, and the history of the trout from the stripping of the ova, through the development of the young, to the catching of the adult fish; common insects, with special emphasis on methods of locomotion and feeding; the unfolding and withering of the One-Day Lily; cultivated flowers; wildflowers, etc.

#### 26TH JUNE, 1939

The President, Mr. F. Smithies, presided.

The following new members were proposed:—Miss Browne, Mr. J. Dumaresq, Mr. G. Crawford, Mr. R. Hall, Mr. W. Manson.

Dr. W. P. Holman gave an illustrated lecture, 'A Short History of the Application of Rays in Medicine', of which the following is an abstract.

Dr. Holman introduced his subject by a chronological outline of the early history of irradiation in its clinical application, illustrating his observations with some interesting pictures of pioneer methods of treatment of patients. The story was then traced through the successive stages of evolution to medium therapy, and to the modern practice of deep therapy. Present-day technique and installation were considered in some detail.

The speaker emphasised the importance in the rapid development of X-ray therapy of the co-operation of workers in various fields of science. The parts played by the physicist, the electrical engineer, and the biologist were described and assessed; and a broad sketch given of the general superstructure erected by the medical radiologist. Dr. Holman illustrated his subject with numerous diagrams and lantern slides.

The lecture was followed by a discussion. Those participating included Mr. Smithies, Mr. Lovett, Mr. Phillips, Mr. Dumaresq, and the Secretary.

The Secretary exhibited the stomach-contents of a Seven-Gilled Shark caught recently at Bell Bay, River Tamar. The material included the remains of a fair-sized bird, vertebrae of several sharks, and jaws and other bones of two or three quite large fish.

#### 17TH JULY, 1939

The President, Mr. F. Smithies, presided.

The following new members were proposed:—Dr. W. P. Holman, Mr. J. V. Tanner.

Mr. J. A. Ingles gave a lecture, 'Lightning and Other Natural Phenomena', of which the following is an abstract.

Mr. Ingles dealt particularly with investigations he had carried out while engaged on the construction of a transmission line in Canada. Lightning, he pointed out, was a problem of distinct interest to an electrical engineer, owing to the readiness with which it could cause serious damage to transmission lines, with consequent interruption to the power supply. On his arrival in Canada, he continued work on a series of experiments begun in France, which seemed to indicate that lightning occurred with greater frequency when there was an excess of negative ions in the air. The economic implications of the liability of electrical supply and the distribution systems to damage from lightning were explored in some detail.

In treating of the other natural phenomena noted in the title of his address, Mr. Ingles presented some very interesting facts regarding the setting up of vibratory movements in transmission lines by winds of quite moderate velocity.

A full and interesting discussion, in which a number of members participated, followed the address.

#### 21ST AUGUST, 1939

Mr. A. L. Meston gave a lecture, 'Ruined Cities of Southern Rhodesia', of which the following is an abstract.

Mr. Meston gave a general account of some of the remarkable ruins of Southern Rhodesia, which he had the opportunity of inspecting during his recent trip overseas. Special attention was paid to the ruins at Inangya, Zimbabwe, and Mapungubwe.

The speaker pointed out that unfortunately many of the ruins had been rifled, and, in some instances, partly destroyed long ago, with the result that much valuable data that might have thrown further light on the problems presented by these curious relics of bygone civilisation had become irretrievably lost. With the aid of diagrams and scale-plans the general topography of the regions under discussion was examined, and the peculiar geographical features of the sites selected by the builders were made clear. Various theories of the origin of the ruined cities were reviewed, and Mr. Meston suggested the available evidence pointed to the earliest of the structures having been erected about 900 A.D. by the ancestors of the existing Bantu race.

The lecture provoked a full and interesting discussion in which Messrs. Allen, Phillips, Evershed, Smithies, Skemp, and Scott participated.

#### 18TH SEPTEMBER, 1939

The President, Mr. F. Smithies, presided.

Mr. P. H. Bond delivered a lecture, 'Science and the Farmer,' of which the following is an abstract.

Mr. Bond began his address with a survey of farming methods and conditions, at home and abroad, at the beginning of the 19th Century. Dealing particularly with Australian conditions, he showed how a natural course of development, with increase in population, gradually led to the exploitation of small holdings, thus creating urgent problems regarding adequate production, and, in the case of stock, disabilities arising from congestion. The speaker proceeded to trace the measures evolved by the farmer and the agricultural expert in collaboration to meet the demands of the new conditions.

In illustration of this aspect of his subject, Mr. Bond cited, and discussed, a number of examples of successful research work, directed towards control of pests, increase of soil-fertility, production of disease-resisting strains of wheat, and general improvements in stock-raising and wheat-growing.

It was pointed out that nowadays a farmer must have, in addition to his agricultural knowledge, at least a passing acquaintance with the skilled trades, some idea of engineering principles, and a smattering of the major sciences. The speaker deplored the tendency of the present educational system to urbanise the country boy, who, after all, was the person most likely to be successful on the land.

The lecture was followed by a discussion, in which Messrs. Evershed, Smithies, Allen, and Dumaresq participated.

#### 16TH OCTOBER, 1939

In the absence of the President, Mr. W. R. Rolph presided.

Mr. E. O. G. Scott gave an address, 'Modern Museum Developments', of which the following is an abstract.

Mr. Scott pointed out that the old conception of a Museum as a building in which miscellaneous specimens and curiosities were preserved in cases, and to which the public were at certain times given access was now being rapidly superseded by a more liberal and enlightened view of its functions and potentialities. The modern Museum does not content itself with a merely passive attitude, but adopts a positive policy calculated effectively to discharge a three-fold function—namely the conservation, the increase, and the diffusion of knowledge. In a general Museum these three functions should be approximately co-ordinate.

The evolution of the new conception of the Museum was traced with the aid of a series of symbolic diagrams. In concluding his remarks, the speaker touched upon some of the outstanding developments observed in Museums studied during his trip abroad last year.

At the conclusion of the talk, a selection of Museum literature was handed around, and formed the basis of an interesting discussion.

#### COUNCIL MEETINGS

Council Meetings were held on 26th April, 4th June, 3rd July, 8th August, 9th October, 18th November.

PAPERS AND PROCEEDINGS  
OF  
THE ROYAL SOCIETY  
OF TASMANIA  
FOR THE YEAR  
1940



10853

Edited by  
JOSEPH PEARSON

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PUBLISHED BY THE SOCIETY  
The Tasmanian Museum and Art Gallery, Hobart.

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1941

*Price: Ten Shillings*



# Royal Society of Tasmania

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## Papers and Proceedings. 1940

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## Preliminary Survey of the Vegetation near New Harbour, South-West Tasmania

By

CONSETT DAVIS, M.Sc.

*Lecturer in Biology, New England University College, Armidale, N.S.W.*

(Communicated by the Secretary)

(Read 11th November, 1940)

### PLATES I-IV

Little has been written about the plant ecology of Tasmania, even from the purely descriptive viewpoint, and the south-west parts of the island, accessible only with difficulty, have been almost entirely neglected in the matter of vegetational studies. The paucity of existing information will, it is hoped, excuse the publication of the present rather meagre details of this interesting region.

The area studied (Text fig. 1) extends from Cox's Bight and New Harbour, bays near the western end of the south coast of Tasmania, northward to the head of Bathurst Channel and its extension Melaleuca Creek, which comprise the south-eastern arm of Port Davey, the large harbour on the southern part of the West Coast. Studies were also made of the vegetation near the mouth of Bathurst Channel, on its north side (Bramble Cove, Roaring Beach, and the slopes of Mt. Berry). For comparison, other comparable districts of Tasmania (Central Plateau, Central West Coast) were cursorily examined at other times.

The details given in this paper were recorded during two short visits, in January, 1937, and February, 1938. Although no record has been taken of the appearance of the vegetation at other seasons, the months of January and February happen to be beneficial for the recording of floristics, as most plants are conspicuous at this season, nearly all being in flower.

No exact records of the climate of the New Harbour district are available, but general data indicate that the district possesses at and near sea-level a climate which would be regarded elsewhere in Australia as a high mountain climate, representing a combination of extreme cold and high rainfall, the latter being estimated to be of the order of 100 inches per annum. The prevailing cold south-westerly winds are probably effective in conditioning vegetational distribution, and the high excess of precipitation over evaporation favours the development of swamps.

Three formations occur in the district, viz., temperate rain-forest, wet sclerophyll forest, and high moor (*Gymnoschoenus sphaerocephalus* community),



of which the last-named is by far the most important as regards total area covered. Climatically and edaphically, the area presents an environment transitional between that required for sclerophyll forest and that for high moor; the inter-relationship of these formations, and of the post-climax rain forest, renders the district extremely interesting, although it makes difficult and even arbitrary any classification in terms of the climax.

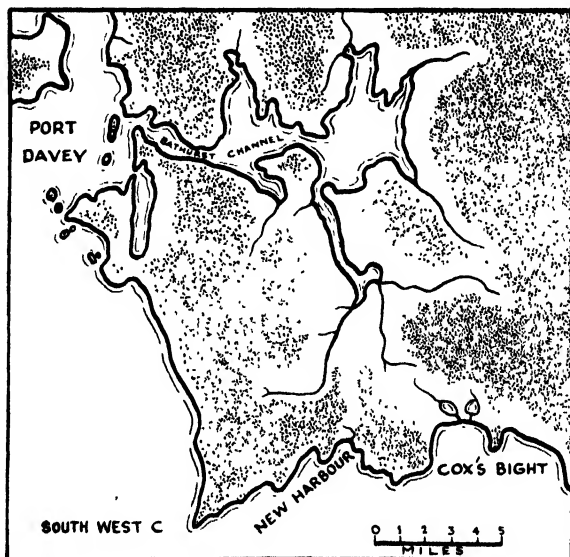


FIGURE 1.—Sketch-map of the New Harbour District. Stippling indicates approximately the distribution of high land.

#### THE *GYMNOSCHOENUS SPHAEROCEPHALUS* COMMUNITY

The community recognized under this name (Davis, 1941) in New South Wales, where it occurs as rather localized moors on the uplands of the South Coast, reaches its full development in Tasmania, where it is known generally by the appropriate name, 'Button-Grass Plains'. It covers a greater area in Tasmania than any other single plant community, and is particularly well developed in the New Harbour district and throughout South-West Tasmania generally.

The community covers practically the whole of the flat area between the head of Bathurst Channel on the one hand and Cox's Bight and New Harbour on the other. It also extends from the flats up the sides of the surrounding hills, until the tops or upper slopes, which are devoid of vegetation, are reached. On the western slopes (with easterly aspect), the community is much interrupted by forest. Almost the entire area investigated between Bramble Cove and Roaring Beach is also covered by the *Gymnoschoenus sphaerocephalus* community.

In facies and floristic content, the communities near New Harbour seem to be typical of those elsewhere in Tasmania, e.g., the more localized patches near Lake St. Clair on the Central Plateau (at 2500 feet approximately); in the least disturbed parts of the Queenstown district; along the Pieman River; and around Strahan, where, however, some of the expressions are rather atypical, with more shrubs. In all these cases, the community is much richer floristically than in its expressions in New South Wales.

The dominant, *Gymnoschoenus sphaerocephalus* (R.Br.) Hook.f. (Plate III, fig. 1), is a tussocky hemicryptophyte, reaching 2-4 feet in height in the New Harbour area. The community is predominantly chamaephytic, hemicryptophytic, and cryptophytic, the cryptophytes being referred to the helophyte class in view of the usually wet nature of the soil. On the upper slopes of the hills, *Gymnoschoenus* becomes less prominent in the shallower soil, and other sedges such as *Elynanthus capillaceus* tend to displace it as dominant. The shrub element is not prominent, although even in the most typical parts of the community species technically classed as nanophanerophytes are present; many of these, however, are slender and weak in growth, and in some cases are classed as nanophanerophytes although a good proportion of the specimens of the species just fail to reach the required height. In the drier parts of the community, woody shrubs increase in abundance.

The floristics of the community, as recorded at New Harbour and in the surrounding district, are as follows ('):

#### Nanophanerophytes:

Common: *Boronia pilosa*, *Baeckea leptocaulis*, *Epacris obtusifolia*, *Sprengelia incarnata*, *Euphrasia Brownii*.

Occasional: *Casuarina distyla*, *Agastachys odorata* (°), *Hakea epiglottis* (°), *Boronia pinnata* (°), *Leptospermum myrtifolium* Sieb. (°), *Melaleuca squamea* (°), *M. squarrosa* (°), *Epacris impressa* (°).

Rare: *Cenarrhenes nitida* (°), *Lomatia polymorpha* (°), *Dillwynia cinerascens* (°), *D. ericifolia* (°), *Pultenaea subumbellata*.

#### Chamaephytes:

Common: *Drosera binata*, *Bauera rubioides* (°), *Azorella saxifraga*, *Utricularia dichotoma*, *U. lateriflora*, *Helichrysum pumilum*.

Occasional: *Drosera Arcturi*, *Sphaerolobium vimineum*, *Mitrasacme montana*, *Stylidium graminifolium*.

Rare: *Cassytha glabella* (°), *Pultenaea Gunnii*, *Comesperma defoliatum*, *Ampera spartioides* (°), *Coprosma* ? *repens*.

#### Hemicryptophytes:

Common: *Elynanthus capillaceus*, *Gymnoschoenus sphaerocephalus* (R.Br.) Hook.f., *Hypolaena lateriflora*, *Restio tetraphyllus*, *Xyris gracilis*.

Occasional: *Restio oligocephalus*, *Blandfordia marginata*, *Haemodorum distichophyllum*, *Campynema lineare*, *Hewardia tasmanica*, *Patersonia glauca*.

Rare: *Poa caespitosa* (°), *Schoenus nitens*, *Diplarrhena latifolia*, *D. moraea*.

#### Helophytes:

Common: *Lycopodium densum*, *Leptocarpus tenax*.

Occasional: *Lycopodium laterale*, *Cryptostylis longifolia*.

Rare: *Lycopodium diffusum* R.Br., *Prasophyllum brachystachyum*, *P. fuscum*, *P. patens*, *Pterostylis* ? *parviflora*, *Thelymitra aristata*, *T. venosa*.

In addition to these vascular plants, species of *Sphagnum* are locally common in the wetter parts of the community.

(°) Names used are those given by Rodway (1903) in the Tasmanian Flora. Where names not adopted in this work are used, authors' names are appended.

(°) Drier parts of community only.

(°) Chiefly in the neighbourhood of running water.

(°) Low-growing rooted hemiparasite.

For the 59 species of vascular plants listed, the life-forms are in the proportions: N 31, Ch 25, H 25, HH 19. Omitting species not quite characteristic (chiefly shrubs, most of which are restricted to dry places), the 45 remaining species give: N 16, Ch 29, H 31, HH 24. Even this does not adequately represent the facies and life-form characteristics of the community, as the nanophanerophytes are nearly all tending towards the chamaephyte class, and the cryptophytic species are mostly rare.

Properties of a few soil samples from this community are given in Table 1 (<sup>1</sup>). Factors influencing the distribution of this community, and in particular those inhibiting forest development, are discussed in a later section.

#### SCLEROPHYLL FOREST, PSAMMOSERES, AND SHRUB SUBCLIMAX

The sample of Eucalyptus forest (wet sclerophyll forest) studied most fully was that behind New Harbour beach. This is interpreted as the culmination of a psammosere, the stages of which are accordingly first dealt with.

**FESTUCA LITORALIS STAGE:** Beyond the limit of wave action, the sand of New Harbour beach is clothed over a narrow zone with an almost pure stand of *Festuca litoralis*. The same species, together with *Carex pumila*, occurs in a comparable situation at Cox's Bight. In both places, plants of *Scirpus nodosus* occur occasionally in this zone, while *Poa caespitosa* occurs rather rarely at New Harbour. All these may be classed as hemicryptophytes. Soil properties for a sample from this community are listed in Table 1.

This stage is scarcely represented at Roaring Beach, where the dune, beyond the limit of wave action, rises steeply, and is covered with shrubs. This is a common configuration on West Tasmanian beaches, e.g., near the mouth of the Henty River. The few situations at Roaring Beach where vegetation is developed at a level lower than the shrubs carry the chamaephyte *Mesembryanthemum acquilaterale*, or occasionally, in small sand accumulations, the following species:

**Chamaephytes:** *Scirpus cartilagineus* (incl. var. *propinquus*), *Salicornia australis*, *Plantago Brownii*, *Cotula filicula*.

**Hemicryptophytes:** *Schoenus nitens*, *Oxalis corniculata*.

**SHRUB DUNE:** At New Harbour, the community noted above passes into a zone containing rather widely scattered shrubs, the following being the floristic composition:

#### Nanophanerophytes:

Common: *Leucopogon Richei*, *Ozothamnus cinereus*.

Occasional: *Correa Laurenciana*.

Rare: *Hakea epiglottis*, *Persoonia juniperina*, *Leptospermum lanigerum*, *Ozothamnus scutellifolius*, *Senecio dryadeus* Sieb., *S. laetus*.

#### Chamaephytes:

Common: *Acaena sanguisorbae*.

Occasional: *Colobanthus Billardieri*, *Epilobium confertifolium* H., *E. junceum*, *Mentha serpyllifolia*.

Rare: *Ampera spartioides*, *Stackhousia linariifolia*, *Helichrysum apiculatum*.

#### Therophytes:

Common: *Helichrysum scorpioides*.

Rare: *Leontodon hirtus* L. (introd.).

(<sup>1</sup>) For methods used in the estimation of soil properties see Davis, 1941. Of the loss on ignition figures listed in Table 1 for this and other communities, over 50 per cent, sometimes nearly 100 per cent, represents humus, as indicated by the hydrogen peroxide method.

In addition to these, species of the preceding stage occasionally occur. Properties of a sample of the soil of this community are given in Table 1.

At Roaring Beach, a dense growth of shrubs is developed on the steep dune behind the beach, but, since it has neither the pioneer community developed in front, nor forest (climax?) behind, it is difficult to regard it as a seral stage. In most places, it passes on the landward side into the *Gymnoschoenus sphaerocephalus* community. The floristic composition is listed as an indication of the potential species of the shrub stage of a psammosere, as the similar conditions at New Harbour for some reason fail to give rise to such a variety of shrubs:

**Nanophanerophytes:**

Common: *Banksia marginata*, *Persoonia Gunnii*, *Acacia verticillata* var. *latifolia*,  
*Correa Laurenciana*, *Leucopogon Richei*, *Westringia rigida*,  
*Ozothamnus cinereus*.

Occasional: *Exocarpus stricta*, *Leptospermum myrtifolium* Sieb., *Cyathodes acerrosa*, *Olearia stellulata* DC.

Rare: *Persoonia juniperina*, *Bedfordia salicina*.

**Geophytes:**

Occasional: *Lepidosperma gladiata*.

Rare: *Pteridium aquilinum* (L.) Kuhn.

Some of the larger of the shrubs actually pass into the microphanerophyte class.

**SCLEROPHYLL FOREST:** At Roaring Beach, and in most places on the foreshores of Cox's Bight, the communities behind the beach pass into the *Gymnoschoenus sphaerocephalus* community without any development of forest. At New Harbour, however, Eucalyptus forest (wet sclerophyll forest) is well developed on former beach sand, in the zone behind the communities listed above. (See Plates I, II, and IV, fig. 2.) The trees reach about fifty feet in height, with closed canopy; low trees (and tall shrubs) form a discontinuous but quite marked layer. The lower shrub and ground strata are seldom continuous, but, with fallen timber, are dense enough to impede passage on foot.

Soil properties for this community are listed in Table 1. The following species are recorded:

**Mega- and mesophanerophytes:**

Common: *Eucalyptus ovata*, *E. (?) Sieberiana*.

Rare: *Phyllocladus rhomboidalis*.

**Microphanerophytes:**

Common: *Banksia marginata*, *Drimys lanceolata* Baill.

Occasional: *Cenarrhenes nitida*, *Pomaderris apetala*.

**Nanophanerophytes:**

Common: *Cyathodes acerrosa*, *Zieria macrophylla* Bonpl.

Occasional: *Persoonia Gunnii*, *Correa Laurenciana*, *Pimelea drupacea*.

**Nanophanerophyte (climber):**

Occasional: *Billardiera longiflora*.

**Chamaephytes:**

Common: *Dianella revoluta*.

Occasional: *Urtica incisa*, *Stackhousia linartifolia*, *Brachycome* sp.

**Therophytes:**

Occasional: *Helichrysum scorpioides*.

Rare: *Galium australe*.

This community extends to a depth of only a few hundred yards, giving place on the inner side to the *Gymnoschoenus sphaerocephalus* community. In aerial views of this part of the latter community, lines running as arcs of circles more or less concentric to that of the beach and present sea limit are clearly visible. If these are interpreted as former strand-lines, we must assume that they have at some time carried Eucalyptus forest, which has been displaced by the moor community, the forest maintaining itself only near the beach, where drainage through the porous sand, unimpeded by humus, is more efficient, and where the lateral course of the water draining through the soil is in any case shorter. The apparent ease with which moor is thus able to replace forest must be borne in mind in considerations as to which formation is the natural climax of the region.

Eucalyptus forest is also developed in many other places in addition to that behind New Harbour Beach. On the drier slopes surmounting the moors behind Cox's Bight and New Harbour, and especially those with easterly aspect, forest similar to that behind New Harbour beach occurs. It also occurs on some of the small hillocks within the *Gymnoschoenus sphaerocephalus* community; the species on one such local rise, on the plain north of New Harbour, proved to agree fairly closely with the hind-dune forest, the following additional species being recorded as fairly common: Chamaephyte, *Halorrhagis teucroides*; hemicryptophytes, *Lomaria discolor*, *L. procera*; geophytes, *Histiopteris incisa* (Thunb.) J.Sm., *Pteris tremula*. The occurrence of certain trees in this clump, e.g., *Anopterus glandulosus*, suggests that it tends towards temperate rain forest; the situation, on the west side of the plain, is somewhat sheltered from the west. Properties of a soil sample from this clump of trees are given in Table 1.

TABLE 1

Soil.	Water-retaining Capacity. Per cent.	Loss on Ignition. Per cent.	pH.	Chloride. Per cent.
Sand Dune	59.	3.4, 8.6	7.4	.01
Shrub Dune	71.	14, 20	7.0	.04
Dune Forest	200.	58, 64	5.7	.32
Eucalyptus Forest (clump in middle of swamp)	220.	47, 48	6.1	..
<i>Gymnoschoenus sphaerocephalus</i> Community	{ 108.	33.	4.8	.
	{ 121.	46.	4.3	....

On some of the ridges behind Cox's Bight, different species of Eucalyptus (*E. amygdalina*, *E. linearis*) are dominant. No explanation for this difference can be suggested.

**SHRUB SUBCLIMAX:** On the cliffs around New Harbour, especially those on the east side, the soil is too shallow and unstable for tree development, but is well-drained, so that shrubs are developed rather than the *Gymnoschoenus sphaerocephalus* community. The same type of vegetation occurs on some of the islands in the district, e.g., Breaksea Island in the mouth of Port Davey. As conditions of erosion indicate that these shrub communities have little prospect of proceeding by succession to forest, they are regarded as subclimax vegetation rather than as a stage of a lithosere.

The following species occur in the shrub community at New Harbour:

**Nanophanerophytes:**

Common: *Banksia marginata*, *Leptospermum myrtifolium* Sieb.

Occasional: *Persoonia Gunnii*, *Drimys lanceolata* Baill., *Acacia verticillata* var. *latifolia*, *Correa Laurenciana*, *Cyathodes acerrosa*, *Leucopogon collinus*.

**Hemicryptophyte:**

Common: *Blechnum cartilagineum*.

**Geophyte:**

Common: *Pteridium aquilinum* (L.) Kuhn.

### TEMPERATE RAIN FOREST

This formation is, in Tasmania, dominated characteristically by *Nothofagus Cunninghamii* (Hook) Oerst., which may be displaced locally by other lower trees, e.g., *Eucryphia Billardieri*, *Anopterus glandulosus*, *Anodopetalum biglandulosum*. These give the vegetation an entirely different facies, but the areas (e.g., those dominated by *Anodopetalum*, the 'Horizontal Scrub') may still be regarded as belonging to the formation.

In its characteristic form, dominated by *Nothofagus*, the formation in the New Harbour district seldom reaches within several hundred feet of sea-level, as it does on the Central West Coast (King River). This is probably due merely to the lack of suitably sheltered areas at low levels. In the sheltered gullies in hills north-west of New Harbour (easterly aspect), pockets of the community, which may be called the *Nothofagus Cunninghamii* association, are developed, apparently typical of the association as expressed elsewhere in Tasmania. The dominant, a tall tree, has a closed canopy; low trees (e.g., *Anopterus glandulosus*, *Drimys lanceolata* Baill.) are present rather sparsely; the ground flora is composed chiefly of ferns (e.g., *Lomaria procera*), and is discontinuous. Small vascular epiphytes (e.g., *Hymenophyllum flabellatum*) are common, as well as bryophytes. The interesting epacrids, *Richea scoparia* and *Dracophyllum Milligani* Hk., occur occasionally.

Along some creeks, e.g., in the *Gymnoschoenus sphaerocephalus* community, where there is insufficient shelter for *Nothofagus* to develop, some of the elements of the formation occur as low trees (e.g., *Anodopetalum*, *Anopterus*). In the sheltered part of a small gully at the south end of Roaring Beach, *Anopterus* dominates a small community which may be regarded as low-grade rain-forest. In these situations, units of the other formations, e.g., *Epacris impressa*, *Cyathodes acerrosa*, are often present.

### DISCUSSION

The variables which, as units of the total environment, govern the vegetational pattern in the New Harbour district may be subdivided as follows, gross climate (as opposed to microclimate) being taken as a constant:

**Topography:** The contour of (a) land surface and (b) bedrock surface (never of course coinciding where vascular vegetation is present) are primary factors in vegetational distribution. The former is important in respect to shelter, and temperate rain-forest is restricted to locations sheltered from the prevailing south-west winds. Land form is also important with respect to drainage, hillocks and ridges, with water-table lower than flat or undulating land, being necessary for forest development in such a wet climate, except where the soil is deep and permeable (e.g., in some rain-forest gullies and in the forest of the psammosere at New Harbour beach). The contour of bedrock is chiefly important in its effect on

drainage, although, in so far as it represents the depth of the soil, it is effective in limiting forest development, e.g., in the shrub subclimax of the shallow soils of the cliffs near New Harbour.

Most of the soils of the plains behind New Harbour and Cox's Bight are relatively shallow, six feet being judged an average from inspection of the various tin workings, and the surface of the underlying impermeable quartzite rock is fairly level. These conditions are conducive of a high water-table. Immediately beside many of the creeks, however, the water-table is lower and small trees of *Eucalyptus* spp., and shrubs, are present (Plate I). This apparent paradox is explained by Text fig. 2; the creeks have steep or vertical banks, and the water has cut through to the underlying rock; the banks are therefore better drained in all cases than those parts of the *Gymnoschoenus sphaerocephalus* community away from creeks. It should not be overlooked, however, that some few shrubs (e.g., *Leptospermum myrtifolium* Sieb., *Melaleuca squamea*) are able to grow in the wettest situations.

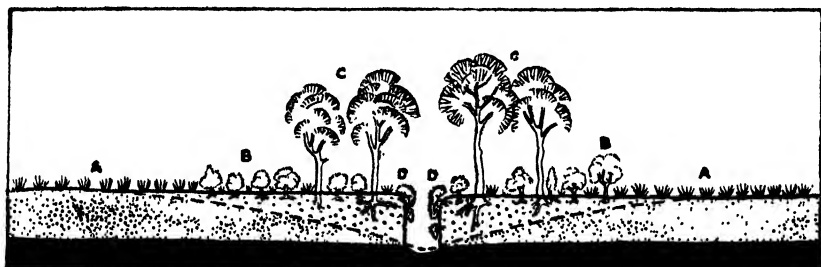


FIGURE 2.—Diagrammatic section across a creek in the *Gymnoschoenus sphaerocephalus* community, plain north of New Harbour. Horizontal scale 1 inch = 10 yards; V/H = 3/1. Black, quartzite rock; heavy stippling, water-logged soil; light stippling, soil not water-logged; broken line, water table.

A, *Gymnoschoenus sphaerocephalus*; B, shrubs; C, low trees; D, straggling plants such as *Baueria rubioides*, *Epacris impressa*, &c.

It has been noted that, while temperate rain-forest is confined to positions of easterly aspect, even *Eucalyptus* forest seems to prefer the western (east-facing) hills, though occasionally forming on west-facing slopes (e.g., immediately north-east of New Harbour). This may mean that the development even of trees of *Eucalyptus* is inhibited in part by the prevailing winds, but another (perhaps supplementary) explanation can be offered. The dip of most of the strata, which consist of much-altered sedimentary rocks, is to the east, and on the westerly-facing slopes the weathered ends of successive strata tend to impede water flow, and favour the development of moor instead of forest; on the east-facing slopes, the contour of rock surface is parallel, more or less, to the bedding planes, and drainage is facilitated.

**Rock Type:** This aspect of the investigation received too little attention, but a few preliminary notes may be put on record. In the first place, humus development and accumulation are so favoured by the climate that the texture of the original soil (i.e., as derived from rock decomposition, without the modification caused by humus) is less important than in some climates (cf., e.g., Davis 1941, with regard to the Bulli district, New South Wales, where humus content is generally low, and only in special situations is able to counteract the coarseness of texture of some soils in its effect on water-retaining capacity). The very high water-retaining capacity of the dune forest soil (200 per cent) may be cited as a

case in point, as dune sand less humus is one of the poorest of water-retainers (\*). Here, the very coarseness and porosity of the dune soil seems to favour, rather than retard, the presence of a higher type of vegetation (sclerophyll forest as opposed to moor), if the swamp behind the dune forest has been correctly interpreted as a corollary to the progress of the psammosere.

In spite of the fact that the high average humus content rather discounts the effect of the soil texture as derived from the parent rock, it seems that forest, and especially rain-forest, is favoured by slate areas rather than the prevailing quartzite and granite in this district. This may perhaps be explained by the greater ease of weathering of the slate, and therefore the deeper soil of these areas, where the more deeply underlying bedrock has less effect in retarding drainage.

Any attempt to classify the vegetation in terms of the climax, under the concept that this is primarily controlled by climate, must be arbitrary in a zone transitional in climate between two types characterized by two recognized climax formations. Two schemes can be suggested: (1) Sclerophyll forest is the climax, moor is a subclimax due to physiographically-controlled high water table, and rain-forest postclimax. (2) Moor is the climax, sclerophyll and rain-forest primary and secondary postclimaxes. Actually, the region seems to be intermediate between that with moor as the climax formation, and that with sclerophyll forest. If any definite scheme is to be adopted, the second of those above seems preferable, as the moor formation is the most important spatially, and also since forest apparently passes into moor at the close of the psammosere.

The life-form spectrum of the moor formation is suggestive of a swamp community in any climatic zone, the life-forms which predominate giving little direct indication of the climate, but rather being characteristic of the soil conditions. Fires are frequent in the *Gymnoschoenus sphaerocephalus* community in the New Harbour district, spreading spontaneously when started even in damp and misty weather; if the hemicryptophytic and helophytic life-forms have any significance, it is probably in their survival value in the event of burning.

My thanks are due to Dr. F. Rodway, of Nowra, for identifying many of the specimens collected, and to Mr. S. Fowler, of the C.S.I.R. (Fisheries Division), for permission to use aerial photographs taken by him.

#### REFERENCES

- DAVIS, C., 1941.—Plant Ecology of the Bulli District, Part ii, *Proc. Linn. Soc. N.S.W.*, lxvi, 1-2  
RODWAY, L., 1903.—*The Tasmanian Flora*. Govt. Printer, Hobart.

(\*) It should be noted, nevertheless, that the sand at New Harbour is of finer texture than that usually encountered in New South Wales; its W.R.C. is 59 per cent, as opposed to 30 per cent as an average for soils of this stage in New South Wales with corresponding loss on ignition.



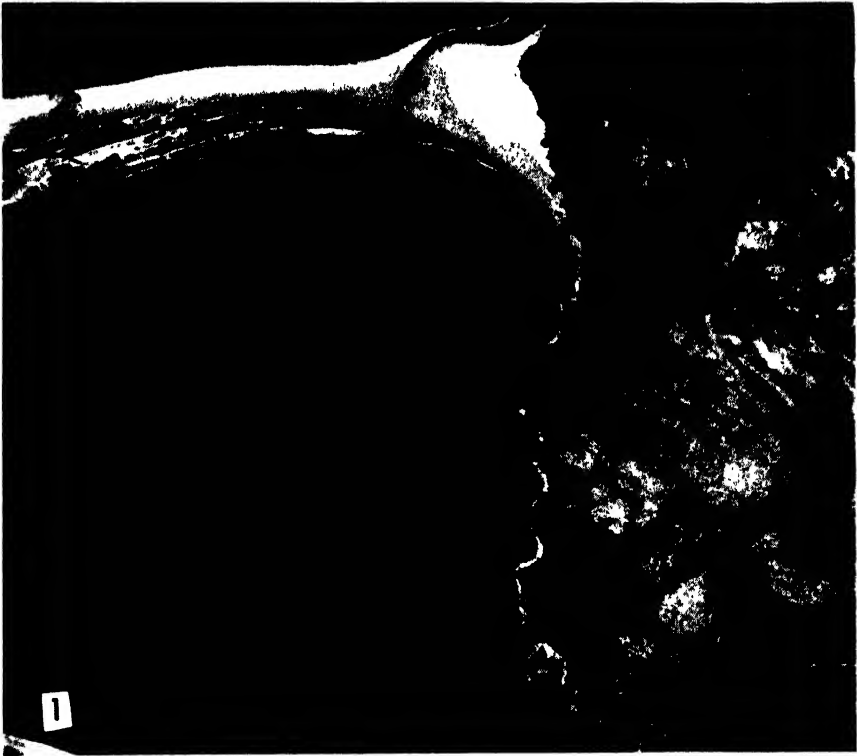
#### PLATE I

Oblique aerial photograph of New Harbour, looking south-west. Psammosere behind beach, Eucalyptus forest (other than that of psammosere) on ridges east of New Harbour Creek, and on parts of the cliffs of New Harbour; shrub communities on cliffs east of New Harbour. Elsewhere, the *Gymnoschoenus sphaerocephalus* community is present, except on weathered hill-tops devoid of vegetation. The tendency for tree development along the banks of New Harbour Creek, well back from the dune zone, is also visible.



## PLATE II

1. Vertical view of north-east corner of New Harbour, north side to the top. Vegetation comprises psammosere (behind beach), and *Gymnoschoenus sphaerocephalus* community, except where bare rock is exposed (hill-tops), or where better drainage permits shrub development on the cliffs on the right (east) side.
2. Oblique aerial view of New Harbour, direction of view south of east; Cox's Bight in the background. Psammosere behind beach, *Gymnoschoenus sphaerocephalus* community rising to bare rock on hill-tops, and shrub communities on shallow well-drained soil on cliffs immediately above the sea, east of New Harbour.



### PLATE III

1. *Gymnoschoenus sphaerocephalus* community, near Cox's Bight.
2. Looking south-east towards Cox's Bight, from hills between Cox's Bight and New Harbour. The entire plain is covered by the *Gymnoschoenus sphaerocephalus* community, which extends up the surrounding hills until the bare rock zone is reached.
3. Ridges behind and to the east of the beach, New Harbour, with *Gymnoschoenus sphaerocephalus* community, and Eucalyptus forest in positions of better drainage.



PLATE IV

1. Hills behind and to the west of Cox's Bight, with easterly aspect. *Gymnoschoenus sphaerocephalus* community, with a pocket of temperate rain-forest in a well-drained gully sheltered from the west.
2. Psammosere, New Harbour beach, looking north-east: *Festuca litoralis*, shrub dune, and dune forest. The hills in the background are partially covered with the *Gymnoschoenus sphaerocephalus* community.
3. Roaring Beach, Port Davey: Shrubs developed on steep slope of blown sand behind the beach elsewhere, the high water-table limits the vegetation to *Gymnoschoenus sphaerocephalus* community.
4. Cliffs in the New Harbour district, with shrub subclimax developed on well-drained but shallow and shifting soil.







## The Lower Tertiary (Miocene) Marine Sedimentary Rocks of the Far North-Western Districts of Tasmania

By

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(Read 11th November, 1940)

The main objectives of this paper are to bring together all references to Tertiary marine rocks; to publish together the various lists of fossils determined from time to time and some of which have not been published; to publish a list of fossils from Marrawah as determined by Mr. F. Chapman in 1932-1933 (see Appendix), and to determine the age of the rocks in accordance with the palaeontological evidence. The age of the rocks is important because that of other rocks (e.g., basalt) in the same region is dependent upon the age of the Tertiary marine rocks.

The far north-western districts are those to the west of a line joining Montagu and Balfour, and they represent the extreme north-western portion of the State (see map).

The generic and specific names of fossils are those given in the original descriptions of the palaeontologist who examined the specimens.

### REVIEW OF THE LITERATURE

The rocks now referred to as Tertiary marine rocks were discovered by P. E. de Strzelecki who carried out scientific exploratory trips in New South Wales and Van Diemen's Land in 1841 and 1842. Strzelecki, however, referred to these rocks as 'elevated beaches', and reported their occurrence at Green Is., south-west point of Flinders Is., Table Cape, and ten miles south of Cape Grim. His description of the latter locality is: 'At ten miles south of Cape Grim and west coast of Van Diemen's Land are found, at 100 feet above the present sea, elevated beaches, similar to those of Bass's Straits, and approaching in structure to a coarse and porous sandstone'. No fossils were recorded (Strzelecki, 1845).

R. C. Gunn (1855) referred to raised beaches on certain parts of the north-west coast, but those referred to are of Recent and not of Tertiary age.

The Table Cape beds became the best known of the deposits discovered by Strzelecki as, according to Stephens (1870) several collections of fossils had already been donated to the Tasmanian Museum. Stephens' paper was written

to illustrate the geology of the North Coast, on the occasion of the presentation of a larger collection of fossils by Mr. Hainsworth. Stephens in this paper referred to the Table Cape beds as Tertiary marine beds, and was apparently the first to do so.

Johnston (1879) described certain Tertiary and Post-Tertiary beds on Flinders and other islands in the eastern part of Bass Strait, and also made brief mention of those at Table Cape, 10 miles south of Cape Grim, and Hunter's Island. Johnston stated that the 'elevated beaches' of previous writers had been shown by recent investigations to be 'remains of the floor of a vast but shallow sea of supposed miocene or oligocene age'. In this he followed the expressed opinion of Tenison-Woods (1877).

During 1875 and succeeding years, Tenison-Woods, Johnston, and others described fossils from the Table Cape beds, but the rocks and fossils from the Table Cape locality will not be further considered in this paper.

Johnston (1888) refers to Strzelecki's discovery of 'elevated beaches' 10 miles south of Cape Grim, and states that, while he had not visited the beds, samples of polyzoal limestone had been sent to him by Messrs. Emmett and J. Norton-Smith, who described the cliffs south of Cape Grim as consisting mainly of horizontally bedded polyzoal limestone capped by basalt. Mr. Smith also reported that the limestones appeared to the east in the valley of the Welcome River. Johnston recognized the following fossils:—

Polyzoa	<i>Cellepora gambierensis</i> (Busk)
	———— <i>spongiosa</i> (Busk)
	———— <i>nummularia</i> (Busk)
	———— <i>hemispherica</i> (Busk)
	<i>Lepralia</i>
	<i>Eschara</i>
Corals	<i>Placotrochus deltoideus</i> (Duncan)
Echinodermata	<i>Lovenia Forbesi</i> (Woods and Duncan)
Brachiopoda	<i>Waldheimia grandis</i> (T. Woods)

Twelvetrees (1908) referred to the polyzoal limestone near Cape Grim and the Welcome R., but the descriptions are based upon those of Johnston (1888).

During the course of the geological survey of the Mt. Balfour Mining Field, L. K. Ward (1910) discovered Tertiary limestones near Temma and also near Marrawah, the exact localities being—

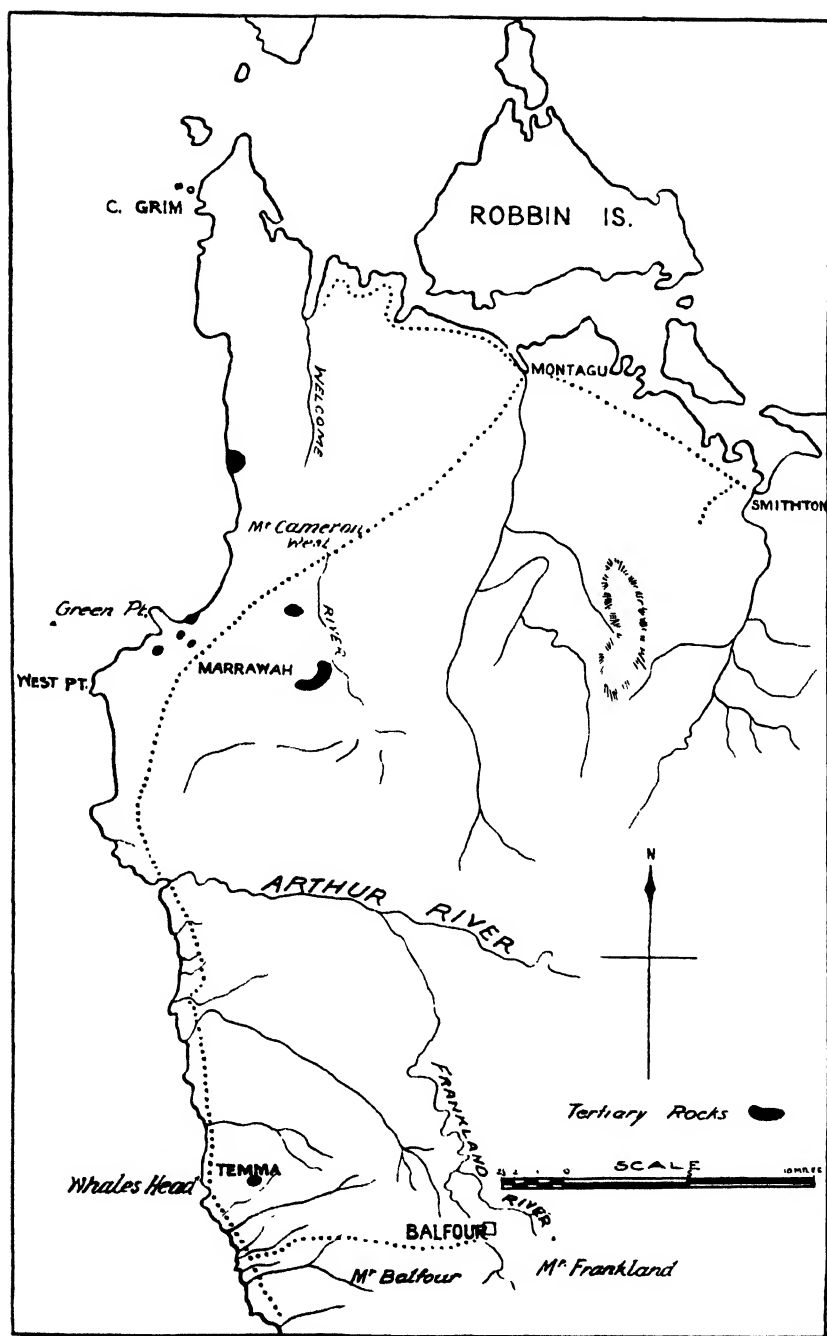
- (1) In the north-western corner of a 99-acre block charted in the name of Louis Hogg. At height of 250 feet above sea level.
- (2) A. Wilson's farm east of Marrawah (Note . . . probably north to north-west of Redpa). At height of 150 feet above sea level.
- (3) On beach close to Marrawah, south of Mt. Cameron west and east of Green Point. Between high and low tide.
- (4) As pebbles on beach between Ordinance Point and Daisy Creek.

The fossils obtained by Ward in 1910 were submitted to W. S. Dun, Government Palaeontologist of New South Wales, who made the following determinations:—

**Locality (2) above**

**Polyzoa:** *Retepora*, *Cellepora*, *Lepralia*, *Microporella*, *Schizoporella* (?)

**Brachiopoda:** *Terebratula garibaldiana*.



**Locality (1) above**

Polyzoa: Most of the polyzoa quoted above.

Brachiopoda: A terebratulid which resembles *T. garibaldiana*.

Gasteropoda: *Marginella*, *Calliostoma*.

Mr. Dun added that 'There is in my opinion every reason to correlate these beds with the Table Cape beds and Cape Grim beds.'

In 1916, Mr. H. T. Lawson submitted some fossils from a limestone quarry at Marrawah (the quarry being about 6 or 7 miles from the coast) to the Geological Survey. The specimens were submitted to Mr. F. Chapman who determined the following fossils (Twelvetrees, 1917).

*Pleurotomaria* sp. (cast) with annectant characters between *P. tertiara*, McCoy, and *P. bassiana*, Pritchard.

*Cypraea* sp. (cast) resembling *C. subsidua*, Tate, or *C. leptorhyncha*.

*Conus* cf. *complicatus*, Tate, and added—

'The relationships of this small collection points unmistakably to the Janjukian (Table Cape) series. The condition of the fossil casts resembles that of the limestones of the Moorabool Valley near Maude, Victoria.'

The friable calcareous sandstones referred to by Meston (1933) in his recent paper on aboriginal carvings on the coast, 10 miles south of Cape Grim are close to Strzelecki's locality and undoubtedly belong to the marine beds of Tertiary age.

**OTHER LOCALITIES**

During 1932, the writer discovered other localities in the Marrawah district, viz.:—

(1) On the western side of the Welcome River plain, 3 miles south-south-east of Redpa. The rock is a hard, pink limestone, horizontally bedded and unconformably overlying steeply dipping beds of Cambro-Ordovician limestone and dolomite. The limestones are fairly extensive and at least 100 feet thick and appear to fringe the basalt hills. The base of the limestone beds is 135 feet above sea-level.

(2) On the eastern portion of G. Loverock's property, one mile west of Marrawah. The rock is white polyzoal limestone. There is no definite outcrop, loose pieces being present in the soil. The extent does not appear to be large and the occurrence is 250 feet above the sea.

(3) On the opposite side of the road to Mr. J. N. Nicholls' house 1½ miles west of Marrawah. Two small quarries in this locality expose a white, polyzoal limestone. The beds are 190 feet above the sea. They cannot be traced beyond the quarries, and the extent does not appear to be large.

(4) Near the south-western portion of J. N. Nicholls' property and on the adjacent property to the south. Several exposures exist in this vicinity at heights ranging from 200 to 250 feet above the sea. The lowest is an excavation at the site of a former spring and reveals a stream of water issuing from a solution channel in white limestone. At a higher level, a small quarry exposes a similar limestone, from which Mr. Nicholls' collection was obtained. On Saward's land block several shafts have been sunk in attempting to obtain a water supply. The material on the dump of the last to be sunk consists of white weathered limestone and brownish mudstones.

The fossils obtained by the writer, together with a private collection loaned by Mr. J. N. Nicholls of Marrawah, were submitted to Mr. F. Chapman, Commonwealth Palaeontologist, in 1932, whose determinations and report are given in the appendix at the end of this report. Mr. Chapman's conclusions were that the age of the limestone was Lower Miocene.

### CONCLUSIONS

Tertiary marine sedimentary rocks have been discovered at numerous places on the north and west coasts of the far north-western districts of the State. While the outcrops are not connected with one another, they represent in some districts the remnants of beds that were once more extensive, and indicate considerable transgressions of the Tertiary sea in such districts. The beds were probably most extensive in the Marrawah - Cape Grim - Welcome River district, though they have since been largely removed by erosion and probably also covered by later sand deposits. The greatest transgression of the sea probably occurred in this district, and extended inland to a distance of at least  $7\frac{1}{2}$  miles from the west coast. The rocks consist mainly of polyzoal limestones, with subordinate amounts of calcareous sandstones and brownish mudstones.

The determinations of fossils from Temma, Marrawah, and Cape Grim prove the rocks to be of Lower Tertiary age, and that they can be correlated with the Table Cape beds further to the east. The latest determination (by Mr. F. Chapman) indicates a Lower Miocene age.

### REFERENCES

- GUNN, R. C., 1855.—On the Encroachments of the Sea along the North Coast of Tasmania, *Pap. Roy. Soc. Tas.*, 1854 (1855), vol. 2, p. 54.
- JOHNSTON, R. M., 1879.—Notes on certain Tertiary and Post-Tertiary deposits on Flinders', Barren, Badger, and other Islands in Bass's Straits, *Pap. Roy. Soc. Tas.*, 1878 (1879), p. 41.
- , 1888.—Geology of Tasmania.
- MESTON, A. L., 1933.—Aboriginal Rock Carvings in Tasmania, Pt. II, *Pap. Roy. Soc. Tas.*, 1932 (1933), p. 1.
- STEPHENS, T., 1870.—Remarks on the Geological Structure of part of the North Coast of Tasmania, with special reference to the Tertiary Marine Beds near Table Cape, *Pap. Roy. Soc. Tas.*, 1869 (1870), p. 17.
- STRZELECKI, COUNT P. E. DE, 1845.—Physical Description of New South Wales and Van Diemen's Land.
- TENISON-WOODS, J. E., 1877.—History of Australian Tertiary Geology, *Pap. Roy. Soc. Tas.*, 1876 (1877), p. 76.
- TWELVETREES, W. H., 1908.—Report of the Government Geologist. *Ser. for Mines Report*, 1908, p. 157.
- , 1917.—Report of the Government Geologist. *Ser. for Mines Report*, 1917, p. 69.
- WAND, L. K., 1910.—Mount Balfour Mining Field, *Tas. Geol. Sur., Bull. No. 10*, 1910.

## Appendix

## Report on a Collection of Fossils from Marrawah, Smithton

(Received from the Tasmanian Mines Department on 20th December, 1932)

By F. CHAPMAN, F.L.S., Commonwealth Palaeontologist

Marrawah, Tasmania	(Private Collection)
Polyzoa	<i>Cellepora coronopus</i> Busk <i>Cellepora biradiata</i> Waters <i>Schizellozoon</i> sp.
Echinoderma	<i>Linthia</i> sp.
Brachiopoda	<i>Magellania grandis</i> (T. Woods) <i>Magellania garibaldiana</i> Dav.
Pelecypoda	<i>Chlamys praecursor</i> (Chapman) <i>Chlamys</i> cf. <i>praecursor</i> (Chapman) <i>Ostrea</i> cf. <i>Hyotidoidea</i> Tate <i>Cypraea</i> cf. <i>leptorhyncha</i> McCoy
Pisces	... .... <i>Isurus retroflexus</i> Ag.

The age of these fossils is Lower Miocene.

## Marrawah, Tasmania (Geol. Surv. Coll.)

## Pink limestone, 3 miles S.E. of Redpa:—

Hard, pink polyzoal limestone. In this section, it consists almost entirely of polyzoal fragments set in a calcitic matrix. A few foraminifera are present, including *Textularia gibbosa*, *Quinqueloculina* sp., and numerous small rotalines; also echinoid plates and spines.

The age of the rock is Lower Miocene. It compares closely with the pink limestone from Mt. Gambier, South Australia, which is also Lower Miocene.

## Limestones, 1½ miles S.S.E. of Green Point, Marrawah:

(a) Weathered, yellowish, polyzoal limestone (with foraminifera (*Carpentaria rotaliformis*), polyzoa (*Cellepora fossa*) and cidaroid plates.

(b) Whitish, marly, polyzoal limestone. Washings contain foraminifera, polyzoa and brachiopoda.

## Foraminifera:—

- Textularia carinata* d'Orb.
- Textularia sagittula* Defr.
- Lenticulina orbicularis* d'Orb.
- Globigerina bulloides* d'Orb.
- Globigerina triloba* Ruess.
- Globigerina* cf. *inflata* d'Orb.
- Carpentaria alternata* Chapm. & Crespin.
- Carpentaria rotaliformis* Chapm. & Crespin.
- Anomalina nonionoides* Parr
- Discorbis turbo* D'Orb.
- Heronallenia lingulata* (Burr. & Holl.)
- Cibicides refulgens* (Montf.)
- Cibicides ungerianus* (d'Orb)
- Cibicides culter* (P. & J.)

*Siphonina australis* (Cushman)  
? *Spirillina decorata* Brady  
*Eponides scabriculus* (Chapman)  
*Eponides karsteni* (Reuss)  
*Elphidium antonina* (d'Orb)  
*Planorbulinella larvata* (P. & J.) var. *plana* H. & E.

*Anthozoa*:—

*Mopsea tenisoni* Chapman  
*Mopsea* sp. nov.

*Polyzoa*:—

*Cellaria australis* McG.  
*Schizolavella phymatopora* (McG.)  
*Acropora gracilis* (M. Edws.)  
*Hornera striata* M. Edws.  
*Idmonea trigona* McG.  
*Idmonea incurva* McG.  
*Lichenopora* sp.

*Brachiopoda*:—

*Murravia triangularis*

The age of these two limestones is Lower Miocene.





# On a Remnant of a Stripped Peneplain of Palaeozoic Age at Mount Sedgwick in Western Tasmania

By

A. B. EDWARDS, PH.D., D.I.C.

(Read 11th November, 1940)

## PLATE V

It is well established (Nye and Blake, 1938, pp. 22, 42) that a peneplain existed over much of Tasmania at the beginning of the Permo-Carboniferous sedimentation. Beds of Permo-Carboniferous and Trias-Jura sediments were laid down on this surface, and, apart from tilting, retain their original horizontal relations. At, or near, the close of the Trias-Jura sedimentation, the intrusion of a dolerite magma occurred on a widespread scale, forming huge dykes and sills. The sills were confined to the horizontally bedded strata, or to the plane of weakness at their base where they rested on the surface of the peneplain.

It is not known whether this peneplain extended to Western Tasmania, or whether it gave place to an irregular erosion surface in that region. The distribution of the Permo-Carboniferous rocks (see below) makes it clear that, even in the latter case, the irregularities of the erosion surface were nothing like as great as those existing to-day. This view is implicit in the opinion of Loftus Hills (1914, p. 25) that at one period 'the central plateau was practically continuous with the West Coast Range, which did not then exist as a separate mountain range'.

## THE STRIPPED PENEPLAIN

At Mount Sedgwick, in the West Coast Range, there occurs a small plateau which appears to be an uncovered portion of this old peneplain. Mount Sedgwick, which is about 4000 feet high, is the highest peak of the West Coast Range in this part of Tasmania (Table I). The summit consists of a pyramidal hill of columnar dolerite, about 300 feet thick <sup>(1)</sup>, portion of an originally thicker and more extensive sill or laccolith. The base of this sill or laccolith is practically horizontal (Plate V, fig. 1), and it lies on a flat surface composed of quartz-felspar-porphry (Devonian age), West Coast Range Conglomerate (Silurian age),

<sup>(1)</sup> T. B. Moore (1894) gives the thickness of the dolerite as 800 to 1000 feet, but this is an exaggeration, and is contradicted by his further statement (p. 148) that he discovered a bed of glacial conglomerate containing coal measure (Permo-Carboniferous) fossils 'at an elevation of 3500 feet above sea-level, adjoining the greenstone on the south-east side of the mount.'

and possibly a small remnant of Permo-Carboniferous sandstone (<sup>2</sup>) at its north-east margin. The dolerite was, therefore, intruded practically between the base of the Permo-Carboniferous at this locality and the Palaeozoic erosion surface.

This surface continues as a small, relatively flat plateau, where it emerges from beneath the dolerite (Plate V, fig. 2). It has been scored by the Pleistocene glaciers, which carved hanging valleys in its margins (Plate V, figs. 1 and 3), and left channels now occupied by lakes. There seems little doubt, therefore, that this plateau, which forms the 'pedestal' on which the dolerite cap of Mount Sedgwick rests, is portion of a stripped peneplain, or of an erosion surface contiguous with the pre-Permo-Carboniferous peneplain that existed in other parts of Tasmania. Some conception of its extent can be obtained from the aerial view of it shown in Plate V, fig. 1. The dolerite summit of Mount Sedgwick appears on the right, and the dolerite-capped peaks of the Eldon Range show in the centre background. The photo is reproduced by the courtesy of Messrs. Nankivell, of Queenstown.

The surface of this uncovered erosion surface stands at about 3700 feet above sea level (<sup>3</sup>), and is not greatly lower than the present summits of the other mountains of the southern end of the West Coast Range (Table 1).

TABLE 1

Mountain.	Height above Sea-level.	Source.
	Feet.	
Sedgwick	4000	Blake
Tyndall	3875	Moore (1893)
Giekie	3950	Moore (1893)
Jukes	3790	Loftus Hills (1914)
Sorell	3730	Loftus Hills (1914)
Owen	3600	Loftus Hills (1914)
	3800	Gregory (1904)
Darwin	3340	Loftus Hills (1914)
Huxley	3200	Blake
Lyell	3050	Gregory (1904)

If its level is assumed to represent the general level of the erosion surface or peneplain in this region, then it is apparent that several of the present mountains formed monadnocks rising several hundred feet above the level of the peneplain.

#### POST-PALAEOZOIC FAULTING

Similar monadnocks also occurred further to the west, because granite pebbles, presumably derived from the Heemskirk massif, have been found near Zeehan in a tillite which is regarded as belonging to the basal stage of the Permo-Carboniferous (Twelvetrees and Ward, 1910, pp. 9, 42). Mount Heemskirk (2700 feet) and Mount Zeehan (2500 feet) stand considerably higher than this tillite, and presumably they stood still higher at the beginning of the Permo-Carboniferous.

(<sup>2</sup>) Fossiliferous sandstones containing casts of *Spirifer* and *Aviculopecten* have been collected from this point by Mr. W. Morris of the Survey Staff of the Lyell Comstock Mine.

(<sup>3</sup>) T. B. Moore (*loc. cit.*, p. 147) refers to Mounts Tyndall and Sedgwick as rising '1500 to 1600 feet above an elevated plateau, on which are situated Lake Dora and numerous other lakes and tarns at an altitude of 2400 feet above sea-level.' R. M. Johnston (*Proc. Roy. Soc. Tas.*, 1893, p. 100) also refers to 'the 2182 to 2400 feet plateau at their bases' (i.e., bases of Mounts Tyndall and Sedgwick). This plateau is not to be confused with the small peneplain remnant which is part of Mount Sedgwick.

Both they and the tillite are, however, much lower than the stripped erosion surface at Mount Sedgwick, which was also capped by Permo-Carboniferous rocks, so that one is forced to postulate either post-Palaeozoic faulting between these two sets of monadnocks, or that the post-Devonian erosion surface was as irregular as the present-day surface.

Another line of evidence suggests that the former postulate is the correct one. Thus, Voisey (1938, p. 322) places the fossiliferous marine Permo-Carboniferous (Kamilaroi) beds between Malanna and Strahan, and along the northern side of the Henty River, in his Achilles Stage, which in this area is characterized by *Fenestella* and *Spirifer*, while in the Pelion district, where it occurs at a much greater altitude, it is characterized by *Fenestella*, *Spirifer*, and *Aviculopecten*. In view of the reported occurrence of *Spirifer* and *Aviculopecten* in the Permo-Carboniferous remnant at the north-east edge of the dolerite cap of Mount Sedgwick, it seems possible that the lowermost beds of the Permo-Carboniferous at this locality also belonged to the Achilles Stage; and since there is a difference in elevation of about 3000 feet between this locality and that of the Strahan-Malanna-Henty River localities, there is a suggestion (a) that these two localities were at more or less similar elevations at the beginning of the Permo-Carboniferous period, and (b) that the more westerly part of the region was faulted down in post-Palaeozoic times. Nye and Blake (1938, p. 21) suggest that such a fault, with a throw of the order of 2000 to 3000 feet, runs parallel to and west of the West Coast Range (presumably some miles to the west), and continues as far as the north coast.

In view of the dolerite cap on Mount Sedgwick, it is presumed that such faulting did not occur until after the close of the Mesozoic.

#### RELATION TO THE WESTERN COASTAL PLAIN

This remnant of the Palaeozoic peneplain (erosion surface) stands at more than 1500 feet above the erosion surface which Gregory (1903, p. 179) termed the Henty peneplain, and which is now called the Western Coastal Plain (Nye and Blake, 1938, p. 4), and is regarded as having been formed during the Pliocene. The Coastal Plain is now considerably dissected as the result of rejuvenated stream action associated with changes of sea-level during the Pleistocene and Recent.

The difference in elevation between the West Coast Range and the Coastal Plain is not, however, directly due to the Tertiary faulting described above, nor as Loftus Hills (1914, p. 24) has pointed out, is it in any way connected with post-glacial uplift of the region.

The elevation of the West Coast Range conglomerates to their present position relative to the Queen River sandstones and shales in which the coastal plain is cut is thought to be due to Devonian (?) faulting, prior to the peneplanation of the area (Gregory, 1905; Edwards, 1939); and there is nothing to indicate that there has been any later fault movement. Differential erosion during the Tertiary has 'exhumed' this Palaeozoic fault line, so that the scarp which delimits the western side of the West Coast Range (Plate V, fig. 4) is probably a fault-line scarp. The eastern face of the range appears to be simply an erosion scarp; and some possibility exists that this may be true of the western scarp also, since the Queen River series may prove to be of Upper Ordovician, rather than Silurian, age (Hills and Edwards, 1941), in which case much of the evidence for the fault disappears.

Either view of the origin of the West Coast Range supports the contention of Loftus Hills (1914, p. 25) that the King River is an antecedent stream which developed on the surface of the post-Devonian sediments, and subsequently was superimposed on the West Coast Range conglomerates; and that the wide alluvial flats that mark its course at the Long Marsh are caused by the slowing up of the river where it enters its gorge tract between Mount Huxley and Mount Jukes.

## REFERENCES

- EDWARDS, A. B., 1939.—Some Observations on the Mineral Composition of the Mount Lyell Copper Ores, Tasmania, and their Modes of Occurrence, *Proc. Aust. Inst. Min. Met.*, n.s., No. 114, pp. 73-74.
- GREGORY, J. W., 1903.—Some Features in the Geography of North-Western Tasmania, *Proc. Roy. Soc. Vic.*, n.s., 16, I, pp. 177-183.
- , 1904.—A Contribution to the Glacial Geology of Tasmania, *Quart. Journ. Geol. Soc. London*, lx, p. 37.
- , 1905.—The Mount Lyell Mining Field, *Aust. Inst. Min. Met.*
- HILL, DOROTHY, and EDWARDS, A. B., 1941.—Note on a Collection of Fossils from Queenstown, Tasmania, *Proc. Roy. Soc. Vic.*, n.s., vol. liii, Pt. I., pp. 222-230.
- HILLS, LOFTUS, 1914.—The Jukes-Darwin Mining Field, *Geol. Surv. Tasmania*, Bull. 16.
- MOORE, T. B., 1894.—Discovery of Glaciation in the Vicinity of Mount Tyndall in Tasmania, *Proc. Roy. Soc. Tas.*, 1893 (1894), pp. 147-149.
- NYE, P. B., and BLAKE, F., 1938.—The Geology and Mineral Deposits of Tasmania, *Geol. Surv. Tasmania*, Bull. 44.
- TWELVETREES, W. H., and WARD, L. KEITH, 1910.—The Ore-Bodies of the Zeehan Field, *Geol. Surv. Tasmania*, Bull. 8.
- VOISEY, A. H., 1938.—The Upper Palaeozoic Rocks of Tasmania, *Proc. Linn. Soc. N.S.W.*, lxiii, Pts. 5-6, pp. 309-333.

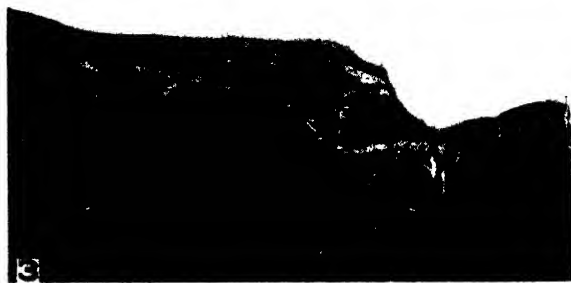
## PLATE V

FIGURE 1.—Aerial view of Lake Margaret, showing the dolerite cap of Mount Sedgwick (on the right) resting on the surface of the Palaeozoic peneplain. Lake Margaret occupies a hanging valley eroded in this peneplain remnant. The dolerite-capped peaks of the Eldon Range show in the centre background. (T. F. Nankivell photo.)

FIGURE 2.—Showing the flat surface of the stripped peneplain remnant where it emerges from beneath the dolerite cap of Mount Sedgwick (eastern side).

FIGURE 3.—A U-shaped hanging valley on the eastern margin of the peneplain remnant.

FIGURE 4.—View of the southern end of the West Coast Range from the Lake Margaret haulage, showing the 'exhumed' fault-line scarp which delimits the western side of the range from the eastern margin of the Western Coastal Plain (dark foreground).





## Studies in Tasmanite Shale Oil

By

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(Read 11th November, 1940)

### INTRODUCTION

Although the chemical composition of petroleum has received much attention in recent years, there is a surprising lack of information from the systematic study of any one shale oil, with perhaps the exception of the work of Kogerman (1931) in Estonia, Hellsing (1921) in Sweden, and Horie (1935) in Japan, together with the various articles which have been published on the Scottish shales. However, practically no work has been published on the chemistry of Tasmanite oil and very little more on any Australian mineral oil.

The oil-producing substance of Tasmanite, seen under the microscope, consists of roundish discs that can be just discerned by the naked eye, although, as Singh (1932) has pointed out, during fossilization these spore cases have been distorted and ruptured. The general consensus of opinion is that they are innumerable sporangia which are allied to Lycopodaceous macrospores. This spore case material is the true kerogen of Tasmanite, and, in common with all shales, its pyrolysis takes place in two stages. A primary decomposition occurs, causing the kerogen to change into a gummy semi-solid bitumen of highly unsaturated nature; this bitumen is unstable at the temperature of the retort, and immediately decomposes into compounds of greater stability and saturation.

The oil taken for this research was produced by a gentle and approximate isothermal distillation of the shale, the temperature never rising above 400°C. There is little or no hydrogen sulphide produced during this pyrolysis, whereas in commercial retorting large quantities of this gas are produced. Assuming that the production of hydrogen sulphide is the result of the secondary decomposition mentioned above, the type of oil chosen for this research should give valuable information on the chemical structure of Tasmanite kerogen.

Research on shale oil presents a more difficult problem than might at first be expected; this is caused by the relatively high percentages of sulphur and nitrogen making the preparation of pure hydrocarbon mixtures very difficult indeed. Another contributing factor is the high olefine content of the oil, which causes the formation of large quantities of tarry matter when the oil is treated with sulphuric acid, in a manner which is applicable to flow oils containing a much smaller amount of this hydrocarbon type.



The crude oil possessed the following properties:—

Specific Gravity @ 15°C	=	0.8540
Refractive Index @ 15°C.	=	1.4684
Water	=	0.34%
Tar Acids	=	4.5%
Tar Bases	=	3.2%
Sulphur	=	2.22%
Nitrogen	=	0.34%
Mercaptan Sulphur	=	0.30%
Diolefines	=	5.7%
Olefines + Aromatics	=	56.1%
Free Sulphur		not present
Hydrogen Sulphide		not present
Acetylenes		present, but not determined
Organic Peroxides		present, but not determined

The above values of the specific gravity and the refractive index; and all proceeding ones in this paper were determined in the following manner:—

*The Specific Gravity* was measured by means of the Westphal balance standardized against distilled water. If any small correction was thought necessary, the amount of the correction was obtained from the data published by Beale (1937).

*The Refractive Index* was found using an Abbé refractometer, and the temperature corrections were based on the Eykman equation and the results of Kurtz and Ward (1936). Except where the temperature is given, both of these constants have been corrected to 20°C. All volumes are volume per cent, and all temperatures are given in degrees Centigrade and are not corrected for the emergent stem.

### *Distillation*

The oil was fractionated in an iron drum of five gallons capacity, with an upright fractionating column at the top. This column was lagged with asbestos tape, between two layers of which was wound a helix of nichrome resistance wire, to a point 10 cm. from the top and to 23 cm. from the bottom, and by this means the column was warmed in the later stages, in order to produce a more even distillation. Inside the column, as a packing agent, were hung six one-yard lengths of brass chain. Towards the end of the distillation it was found impossible to get over the last fractions on account of the heat losses at the sides of the drum, and for this reason the last litre or so were distilled in a small apparatus of the normal laboratory type. Seventeen litres of the oil were distilled, with the results shown in the first four columns of Table I. The colour of the fractions varied progressively from colourless, in the first three fractions, through pale and dark yellow to nearly black in the last fractions.

### *Washing of the Fractions to Determine the Tar Acids and Tar Bases*

100 ml. of each fraction were taken and poured into a stoppered separatory funnel, and an equal volume of 10 per cent aqueous sodium hydroxide added, then strongly agitated and the two layers allowed to separate out, the bottom layer run off, and the procedure repeated until the volume of the residual oil remained constant after two consecutive washings. The decrease in volume of the oil was taken as the percentage of *tar acids*. The above treatment was repeated substituting 10 per cent sulphuric acid for the caustic solution, and in this manner the amount of *tar bases* was determined. This treatment was

followed by a light sodium carbonate treat in order to remove traces of acid, then by a water wash, and finally the fractions were dehydrated over calcium chloride. The results of these treatments are shown in the Table I.

#### *The Isolation of m-Cresol in the Tar Acids*

The caustic washings from seven litres of the oil were united and the crude phenols liberated by dilute hydrochloric acid. They were redissolved in 4N caustic soda and the phenols—free from naphthenic acids—liberated by means of carbon dioxide. The reddish oily liquid was fractionated using a Young and Thomas column.

<i>Fraction No</i>	<i>Boiling Range</i>	<i>Density</i>	<i>Refractive Index</i>
1	183-204	0.9811	1.5346
2	204-207	1.0119	1.5330
3	207-217	1.0178	1.5321
4	217-226	1.0216	1.5287
5	226-231	1.0245	1.5251
6	Residues		

The first and second fractions were united and distilled three times and divided into the following cuts:—

<i>Cut No</i>	<i>Boiling Range</i>	<i>Density</i>	<i>Refractive Index</i>
I	200-203	1.021	1.5201
II	203-208	1.018	1.5220
III	208-214	1.011	1.5281

All three fractions were water-white when freshly distilled, but developed a reddish tinge after a few days. They possessed the characteristic cresol odour, and were practically sulphur free (all thiocresols possess a boiling point lower than 200°C).

#### *Isolation of m-Cresol from Cut I*

This fraction was treated with mercuric chloride in order to remove traces of sulphur compounds, washed with water, and purified by ether extraction. The purified extract was again distilled, when the major portion distilled over at  $204^{\circ} \pm 0.4$ . This was put aside and its characteristics found; density = 1.027 and refractive index = 1.5527, and on distillation with zinc dust it yielded toluene.

Schotten Baumann reaction with benzoyl chloride produced a benzoate of melting point  $53.1^{\circ}$ ; the oil corresponds fairly closely with m-tolyl benzoate of m.p. =  $54^{\circ}$  (Behal & Chozap, 1894), and gave no depression of melting point when mixed with the latter substance. Another portion was nitrated according to the method of Rashig (1901) and the trinitro derivative isolated; this was light yellow in colour and melted at  $104.7^{\circ}$ ; the melting point of 2:4:6-trinitro-m-cresol =  $106^{\circ}$ .

According to Darzens (1931), anhydrous sodium acetate forms with m-cresol a complex  $5\text{CH}_3\text{COONa} \cdot 2\text{CH}_3\text{C}_6\text{H}_4\text{OH}$ , which, on decomposition with water, yields m-cresol in a high degree of purity. This reaction, so the author maintains, is specific to m-cresol. A similar procedure was applied to the purified m-cresol from Tasmanite, with positive results. The m-cresol isolated had a melting point of  $10.5^{\circ}$  and refractive index of 1.5343 at  $20^{\circ}\text{C}$ , agreeing very closely with the data published by Darzens. All attempts to detect the ortho- and para-isomers were unsuccessful.

## THE OLEFINE CONTENT

The determination of the correct olefine content is a matter of great difficulty in an oil such as this. Owing to the colour of the middle and last fractions, methods such as that of Mulliken and Wakeman (1935), involving the use of bromine, could not be used, as even the middle fractions had sufficient yellow colour to mask completely the very similar colour of the bromine. Moreover Thomas, Bloch, and Hoestra (1938) suggest that bromine absorption does not give correct values for the unsaturation when diolefines are present, which is undoubtedly the case in this oil. The use of the Francis bromide-bromate solution (Francis, 1926) was tried in the lower fractions without concordant results, probably due to the presence of cyclic olefines, which, according to Cortese (1929) give anomalous results.

After trying several reagents it was decided to employ sulphuric acid without the addition of boric acid as suggested by Kattwinkle (1927), as this has been shown incorrect by Tropsch and others (1929). It was fully realized that this method possessed many inherent disadvantages, such as the formation of polymerization products, attack on other substances, also the constitution of the saturated hydrocarbons is not necessarily the same before and after the sulphuric acid treatment, as new paraffins and naphthenes may be formed under the influence of the acid (Brochet, 1893).

## OPTIMUM ACID STRENGTH FOR OLEFINE DETERMINATION

In order to gain some idea of the action of different strengths of sulphuric acid on the oil, a representative fraction was treated with gradually increasing strength sulphuric acid, in the manner suggested by Fisher and Eisner (1937). The results of this are shown below:

<i>Acid Strength.</i>	<i>Residual Volume.</i>	<i>Refractive Index.</i>
%	ml	
	100	1.4812
70	93.0	1.4778
75	88.0	1.4785
80	82.5	1.4796
82.5	80.5	1.4800
85	76.6	1.4820
88	60.5	1.4795
90	58.0	1.4765
96	51.0	1.4583
100	44.5	1.4364
105	39.5	1.4385

11  
2 f

From these figures it can be seen that there is incipient attack on the aromatics when the acid strength has reached 88 per cent and that complete removal of aromatics and the commencement of attack on the paraffin-naphthene mixture starts with the 100 per cent acid.

50 ml. of the acid and base-free oil were placed in a stoppered separatory funnel and treated with an equal volume of 85 per cent sulphuric acid for ten minutes with external cooling, the acid layer separated off, and the treatment continued until the volume of the residual oil was constant. The results are given in Table I.

The residual oils were water-white, had practically no odour, and did not decolourize a weak solution of potassium permanganate.

*The presence of Diolefines*

The presence of appreciable amounts of diolefines in the oil was indicated by the intense yellow colour in some fractions. A certain fraction, in which the presence of diolefines was strongly suspected, was placed in a flask with 20 per cent of its weight of maleic anhydride and kept at a temperature of 100°C. for four hours under reflux. At the end of this period the residual oil was decanted off and the crystals washed free from oil; these crystals were soluble in alcohol and melted at 145°. To prove that ring formation had actually taken place, 1.5 gm. of the maleic anhydride compound was heated with 2 gm. of resorcinol and 1 gm. of zinc chloride for several hours. The product of this reaction was an intense red solid, soluble in alcohol, and had a characteristic colour change from acid to alkaline solution. The formation of this coloured substance (to be assumed of the phthalein type) could only arise from a cyclic structure, necessitating ring closure between the maleic anhydride and the diolefine with the formation of an acid similar to terephthalic acid and the subsequent formation of the anhydride.

*The Presence of Terpene-like Olefines*

A series of investigations were carried out in order to determine whether terpenes or substances allied to them were present in the oil. It is not intended to give a detailed description of the work done in this direction, but to state briefly that no conclusive evidence for their presence was obtained, although certain lines of research produced promising results, notably halogenation, followed by treatment with mercuric acetate.

## THE SULPHUR COMPOUNDS

Sulphur is always present in shale, and, in general, a similarity exists between the sulphur compounds in shale oil and those in petroleum, but it is found that aromatic compounds predominate in the oil from shale in contrast to the usual aliphatic nature of the sulphur compounds in petroleum.

An examination of the more important sulphur compounds occurring in shale oil will serve to show that they are essentially thiophenic in nature and for this reason investigations on the sulphur bodies in shale oil are usually more difficult than the corresponding work on petroleum. This is more easily realized when the unsaturated nature of the former is taken into account.

On an allied oil Morgan and Soule (1923) write, 'There is no concentration of sulphuric acid capable of removing such sulphur compounds without attacking the unsaturates which predominate in the neutral oil. These unsaturated compounds, moreover, interfere with the usual qualitative thiophene identifications, by reacting with the sulphuric acid of the indophenin test and with the nitric acid of the thalline test to give reddish brown shades which mask the colour reactions, even in the presence of added thiophene.'

The presence of sulphur compounds in an oil which is to be used for power purposes has been one of the great disadvantages against the employment of shale oil in this connexion, for not only does the sulphuric acid formed during its combustion have a corrosive effect on the cylinders of the engine, but recently Kruser and Schade (1933) have shown that such compounds can act as accelerators in gum formation.

Challenger (1926) and Schleiber (1915, 1916) have performed important investigations into the nature of the sulphur compounds occurring in shale oil; both of the above investigators have shown that these bodies are mainly derivatives of thiophene, and have succeeded in isolating thiophene itself and certain of the lower alkyl homologues.

### EXPERIMENTAL

#### *Mercaptans*

Mercaptan sulphur was estimated by a modification of the method proposed by Bond (1933). The results are given in the first table.

#### *The Thiophenes*

Five litres of crude Tasmanite gasoline were given a light acid and alkali wash and then distilled with the following results:—

<i>Fraction</i>	<i>Temperature Range.</i>	<i>Volume mls.</i>	<i>Density @ 18°.</i>	<i>Refractive Index</i>	<i>Sulphur % by Wt</i>
1	-50	9.6	0.6934	1.3834	0.20
2	50-70	87	0.7037	1.3972	0.53
3	70-90	457	0.7484	1.4088	1.18
4	90-110	491	0.7641	1.4207	1.51
5	110-130	538	0.7884	1.4361	1.97
6	130-150	593	0.7928	1.4389	2.31
7	150-160	163	0.8049	1.4469	3.06
8	160-170	161	0.8112	1.4496	3.58
9	170-180	115	0.8225	1.4558	3.24
10	180-190	91	0.8377	1.4590	3.22
11	190-200	58	0.8400	1.4654	3.02
12	Residues				

Fractions 3 and 4 were united and subjected to more exact fractionation, thus:—

<i>Fraction.</i>	<i>Temperature Range.</i>	<i>Density</i>	<i>Refractive Index</i>	<i>Sulphur % by Wt</i>
3a	70-75	0.7179	1.4003	1.02
3b	75-80	0.7295	1.4073	1.18
3c	80-85	0.7583	1.4232	1.48
3d	85-90	0.7667	1.4180	1.54
4a	90-95	0.7548	1.4205	1.48
4b	95-100	0.7585	1.4300	1.40

#### *The Presence of Thiophene in Fractions 3c + 3d*

A representative portion of these two fractions was again distilled and cut at 2° intervals. The 83°-85° cut was treated with mercuric chloride in the following manner:—Alcohol was added to the fraction until the solution contained 80 per cent alcohol, and to it was added twice the amount of mercuric chloride required to form the mercurichloride (assuming that all the sulphur was contained in the thiophene), and five times the quantity of sodium acetate necessary to combine with the liberated hydrochloric acid. It was allowed to stand for two days with frequent shaking, and at the end of this period the precipitate was filtered off. A portion of this precipitate after purification gave, on analysis:—

Chloride	11.8% found; 11.1 calculated
Sulphur	9.7% found; 10.0 calculated

The melting point of the compound was rather indefinite near 179°, and at 183° it commenced to blacken. The melting point of thiophene mercurichloride is reported by Steinkopf to be 183°. Another portion of the precipitate on distillation with 6N hydrochloric acid decomposed to produce a liquid which reacted positively to the usual thiophene colorimetric tests.

### *The Methyl-Thiophenes*

Fractions 4b and 5 were united and distilled three times.

<i>Fraction No</i>	<i>Temperature Range</i>	<i>Density</i>	<i>Refractive Index</i>	<i>Sulphur % by Wt</i>
MT (i)	105-109	0.7642	1.4246	2.43
MT (ii)	109-117	0.7759	1.4345	2.98
MT (iii)	117-126	0.7808	1.4348	2.27

Lot MT(ii) was fractionated twice, and the final temperature limits taken at 111° to 115°. The volume of this fraction was 67 ml., and it contained 2.99 per cent sulphur. 60 ml. of this were dissolved in a litre and a half of alcohol and agitated with one litre of aqueous sodium acetate (33 per cent) and four litres of saturated aqueous mercuric acetate. After two and a half hours a dirty yellow precipitate formed; this was removed, and further precipitation allowed to take place. At the end of one day the combined precipitates were extracted with boiling alcohol and the solute crystallized and purified. The crystals melted between 202° and 204°. Steinkopf (1914) states that the melting point of 2-methylthiophene-5-mercurichloride is 204° with previous sintering, while the corresponding figure for the 3-methyl isomer is quoted at 138°. The methylthiophene-mercurichloride was decomposed with hydrochloric acid as before, and a portion of the liberated methylthiophene converted into its tribromo derivative. On recrystallization a sharp melting point was obtained at 85.6°. The melting point of tribromomethylthiophene is recorded in the literature at temperatures varying between 87° and 94° but most reliable sources place it at 86°. The melting point of the other isomer is 35°, while Gatterman (1885) states that a mixture of the two isomers cannot be separated by crystallization and melts at 74°. In order to complete the identification a small portion of the purified compound was oxidized to the corresponding acid with potassium permanganate. The melting point of this acid (126°) clearly corresponded to 2-thiophenecarboxylic acid.

### *Examination of Fraction 6 for Dimethylthiophenes*

Fraction 6 was distilled several times and finally cut into two lots:—

6 (a) 130°-135° Density, 0.7854; Refractive Index, 1.4390.

6 (b) 135°-143° Density, 0.8012; Refractive Index, 1.4468.

No thiophene derivatives could be found in the first lot. The other lot, 6(b), gave very peculiar results. 60 ml. were treated with mercuric acetate as before, and, within a half hour, a large amount of white granular precipitate was formed. The mixture was allowed to stand for thirty hours with frequent shaking, after which the precipitated mercury compounds were filtered off. An examination of the filtrate showed that the whole of the fraction had been converted into the mercury compound. The precipitate was washed with petroleum ether, after

which it was distilled with 6N hydrochloric acid, whereupon 57 ml. of a sweet aromatic oil were recovered. The oil burnt with a very smoky flame, and possessed the following properties:—

Density	0.8107
Refractive Index	1.4471
Sulphur	3.0 per cent

It reacted negatively to the usual thiophene tests. On distillation the whole of the distillate came over between 136° and 140°, which immediately precludes other sulphur containing substances, such as thioethers, thiols, thiophanes, &c., none of which have been reported to boil within these limits. In the case of 2:3-dimethylthiophene-mercurichloride, there is a direct covalent link between the mercury and carbon atoms, in contrast to the addition compounds formed when mercury salts act on other sulphur compounds, such as mercaptans. This latter type is split up on treatment with caustic alkalis with the formation of the oxide of the metal. It was proved in the present case that the compound under consideration was essentially aromatic in nature. However, at this juncture it seems inadvisable to assume that dimethylthiophenes are absent, nevertheless it appears that another type of sulphur compound is present in such large quantities that the usual methods used in the isolation of thiophene homologues are not applicable. It is hoped to continue this phase of the research in the future.

These investigations were carried out in the Department of Chemistry in the University of Tasmania during the tenure of a Commonwealth Government Research Scholarship (1938 and 1939).

#### SUMMARY

Tasmanite shale on gentle pyrolysis produces an unsaturated oil with a relatively high aromatic content. The oil was fractionated and the physical properties of the different fractions found, after which the fractions were washed with sodium hydroxide solution and dilute sulphuric acid, in order to determine the tar acids and tar bases. The isolation of m-cresol from the tar acids is described. The degree of unsaturation, as determined by 85 per cent sulphuric acid, varied between 40 per cent and 47 per cent, including as much as 11 per cent diolefines. It is probable that terpenes, or substances closely allied to them, occur in the oil, although their presence was not confirmed. Tasmanite shale oil contains large quantities of sulphur, the major portion of which is contained in heterocyclic molecules. The cyclic sulphur bodies in the lower fractions were thiophenic in nature and the presence of thiophene and methyl thiophene was confirmed.

#### REFERENCES

- BEALE, E. S., 1937. —A Table of Specific Gravity Correction Tables for Petroleum Oils, *J. Inst. Pet. Tech.*, Vol. 23, No 161, p 213.
- BEHAL, and CHOAY, 1894 —*C. R. Acad. Sci. Paris*, Vol. 192, p 1657.
- BOND, G. R., 1933.—Rapid Quantitative Determination of Mercaptans, *Ind. & Eng. Chem. Anal. Ed.*, Vol. 5, p. 256.
- BROCHET, 1893.—The Acid of Montan Wax, *Bull. Soc. Chim.*, Vol 519, p. 687.

- CHALLENGER, F., 1926 —The Sulphur Compounds of Kimmeridge Shale Oil, *J. Inst. Pet. Tech.*, Vol. 12, pp. 106-141.
- CORTESI, 1929 --The Estimation of Unsaturation with Potassium Bromide-Potassium Bromate Mixture, *Rec Trav. Chim.*, Vol 48, p 564
- DARZENS, 1931.--The Separation of Cresols The Properties of pure m-Cresol, *C R. Acad Sci Paris*, Vol 192, p. 657
- FISHER, C H, and EISNER, A 1937 Graphical Analysis of Hydrocarbon Oils, *Ind & Eng Chem. Anal Ed.*, Vol 9, p 367
- FRANCIS, A. W., 1926.--Estimation of the Unsaturation of Petroleum Products, *Ind. & Eng. Chem.*, Vol. 18, p. 821, 1926.
- GATTERMAN, 1885.- *Bericht. Deutsch Chem. Gesell.*, Vol 18, p 3005.
- HELLSING, G, 1921 —Contribution to the Knowledge of Swedish Shale Oils, *Arkiv. Kemi. Min och Geol (Stockholm)*, Vol 7, No 29
- HORIE, F., 1935.—The Chemical Composition of Fushun Shale Oil, *Jour Soc. Chem Ind. (Japan)*, Suppl Binding, Vol. 38,
- KATTWINKEL, R., 1927 —Determination of Aromatic and Unsaturated Hydrocarbon in Benzene by means of Sulphuric Acid, *Brennstoff-Chemie*, Vol 8, p 353
- KOGERMAN, P. N., 1931—On the Chemistry of Estonian Oil Shale 'Kukersite', *University of Tartu*, Bull No 3, May.
- KRUSER, and SCHADE, 1933 *Brennstoff-Chemie*, Vol. 14, p 124
- KURTZ, and WARD, 1936 —Analysis of Light Hydrocarbon Fractions, *Jour Franklin Inst.*, Vol 222, p 563
- MORGAN, and SOULE, 1923 --The Examination of Low Temperature Coal Tars, *Ind. & Eng Chem.*, Vol 15, p 587
- MULLIKEN, S P, and WAKEMAN, R L, 1935 A procedure for the Classification of Hydrocarbons, *Ind & Eng Chem. Anal Ed.* Vol 7, No 4, p. 59.
- RASHIG, F, 1900 --*Zeit. angew. Chemie*, Vol. 31, p 795
- SCHLEIBLER, H., 1915 —Isolation and Identification of some Thiophene Compounds in Shale Oil, *Berichte der Deutsch chem Gesellschaft*, Vol 48, p 1815.
- , 1916 --The Constituents of Bitumenous Shale, rich in Sulphur, *Berichte de Deutsch chem Gesellschaft*, Vol 49, p 2595
- SINGH, 1932 Notes on the fossil spores in an Oil-shale from Tasmania, *Pap. Roy. Soc. Tas.*, 1931 (1932)
- STEINKOPF, 1914.--Mercuric Chloride Derivatives of Thiophene and Homologues, *Annal der Chemie. (Liebig)*, Vol. 403, p. 63, 1914
- THOMAS, C L, BLOCH, H. S., and HOESTRA, J., 1938.--Proximate Analysis of Gasoline, *Ind. & Eng. Chem Anal Ed.*, Vol 10, p 153
- TROPSCH, H, and KOCH, 1929 -*Brennstoff-Chemie*, Vol 10, p 337.



TABLE I.

Fraction.	Temperature Range.	Volume ml	Specific Gravity @ 20°	Refractive Index @ 20°	Tar Acids	Tar Bases	After Removal of Acids and Bases			
							Specific Gravity.	Refractive Index	Olefines Per cent	Mercaptan Sulphur.
A	36-60	60	0.6799	1.3857	0.0	0.5	0.6800	1.3858	40	0.000
B	60-70	414	0.6958	1.4038	0.0	0.5	0.6959	1.4039	40	0.029
C	70-80	162	0.7199	1.4046	0.0	1.0	0.7200	1.4048	16	0.044
D	90-100	227	0.7200	1.4060	0.0	1.1	0.7195	1.4063	47	0.071
E	100-110	125	0.7237	1.4097	0.0	1.0	0.7239	1.4098	16	0.105
F	110-120	256	0.7425	1.4130	0.0	1.1	0.7415	1.4130	45	0.062
G	120-130	261	0.7531	1.4205	0.0	1.1	0.7528	1.4200	11	0.115
H	130-140	497	0.7630	1.4242	0.1	1.4	0.7649	1.4251	15	0.126
I	140-150	544	0.7665	1.4284	0.3	1.6	0.7665	1.4286	45	0.164
J	150-160	529	0.7785	1.4329	0.4	2.0	0.7806	1.4330	14	0.232
K	160-170	956	0.7934	1.4418	0.5	2.4	0.7897	1.4330	42	0.273
L	170-180	841	0.8062	1.4468	1.5	2.5	0.8004	1.4419	40	0.282
M	180-200	910	0.8148	1.4523	2.0	2.5	0.8154	1.4494	40	0.226
N	200-220	2022	0.8298	1.4607	3.0	2.7	0.8277	1.4567	41	0.390
O	220-240	1920	0.8461	1.4657	3.5	3.5	0.8396	1.4612	10	0.507
P	240-260	1873	0.8713	1.4805	3.5	4.0	0.8668	1.4758	10	0.224
Q	260-280	822	0.8779	1.4848	4.5	4.0	0.8763	1.4832	40	0.392
R	280-300	864	0.8803	1.4932	5.0	4.5	0.8761	1.4906	11	0.421
S	300-320	778	0.8978	1.4992	5.0	4.5	0.9858	1.4974	41	0.438
T	320-340	843	0.9161	1.5077	5.5	4.5	0.8999	1.5056	40	0.515
U	340-360	705	0.9328	1.5183	5.5	4.0	0.9311	1.5170	40	0.344
V	360-	175	0.9514	1.5227	5.8	4.0	0.9500	1.5213	40	0.445

# Observations on the Stem Anatomy of the Genus *Richea*(<sup>1</sup>)

By

WINIFRED M. CURTIS

(Read 11th November, 1940)

## PLATE VI

The *Richeas* are essentially Tasmanian plants: widespread and abundant in mountain habitats, certain species are important members of the Austral-Montane formation of mountain plateaux. The genus *Richea*, R. Br., in which Rodway (1903) includes the genera *Cystanthe* and *Ptilitis* of Hooker (1860), comprises eight species: of these, seven are endemic in Tasmania, while one, *R. Gunnii*, common in Tasmania, is found also in the Australian Alps. The species listed by Rodway are:—*R. sprengelioides*, F.v.M., *R. procera*, F.v.M., *R. acerosa*, F.v.M., *R. Milligani*, F.v.M., *R. Gunnii*, Hook., *R. scoparia*, Hook., *R. diacophylla*, R. Br., *R. pandanifolia*, Hook.

The following description is based on the examination of fresh material of all the above species except of *R. Milligani*, for which herbarium material was used. Specimens of the plants collected have been placed in the herbaria of the Royal Botanic Gardens, Kew, and of the University of Tasmania.

The plants are erect evergreen shrubs, ranging in height from 1 ft., in specimens of *R. sprengelioides*, to more than 30 ft., in specimens of *R. pandanifolia*. The leaves, which show a corresponding range in size, from  $\frac{1}{2}$  inch to several feet in length, are xeromorphic and densely crowded on the stems. The phyllotaxis is  $\frac{2}{5}$  or  $\frac{3}{8}$ . The arrangement of the leaves in *R. sprengelioides* is illustrated in Plate VI., fig. 1. A certain degree of variation in the size and habit of the leaves, which may be erect or recurved, is noticeable in the species *R. sprengelioides* and *R. scoparia*. The leaves of all the species are, however, characterized by wide decurrent sheathing bases, which, when shed, leave conspicuous annular scars. This feature readily distinguishes the *Richeas* from the closely allied *Sprengelia incarnata*, Sm.

In all the species of *Richea*, the stems in transverse section show the typical dicotyledonous structure. Growth is slow and secondary thickening may occur at a distance of less than 1 cm. behind the apex. The xylem vessels are small, and regularly arranged: the walls are strongly lignified having bordered pits or scalariform thickening. The vascular tissue is traversed by uniseriate rays.

The structure of the pith and of the primary cortex is of interest. In these regions special excretory receptacles containing large solitary crystals of calcium oxalate, are a prominent feature. The receptacles, consisting of groups of two to sixteen relatively large cells which are crystal sacs, are interspersed between the smaller, thicker-walled cells of the pith and cortex. The crystal sacs have thin cellulose walls, some of which, in the older parts of the stem, may partially

(<sup>1</sup>) Published under the auspices of the Tasmanian Biological Survey.

break down (Plate VI, figs. 2 & 3). While the structure of the receptacles is similar in the pith and in the primary cortex, in the pith the surrounding cells have strongly lignified walls perforated by simple pits, in the cortex the thickening of the corresponding cells is cellulose. These thickened cells of the ground tissue are irregular in shape. The individual cells when isolated by maceration for a few days in a mixture of 10 per cent chromic and nitric acids, are seen to have projections which may interlock with similar outgrowths from adjoining cells (Plate VI, fig. 4). The differentiation of the cells of the pith takes place at an early stage, cells developing into crystal sacs may readily be distinguished in sections taken a few mm. behind the apex of the shoot.

Excretory receptacles, which are a characteristic feature of the stems of every species of *Richea*, are not found in *Sprengelia incarnata*, and they provide an interesting anatomical distinction between these plants. Such receptacles are not described by Solereder (1908) in his account of the anatomical features of the Epacridae, although a reticulate arrangement of large and small cells in the pith of *Richea* is noted.

Cork formation in the stems of the Richeas, as in other members of the family, begins in a deep-seated layer. In every species of *Richea* this is in the phloem immediately within the pericyclic fibres. Solereder states that in the Epacridae no distinct cork cambium is present and 'it almost appears as though the cells of the cork originated from the outer cells of the soft bast'. In the material now examined, although a meristematic layer may be distinguished, this is somewhat irregular, and the cells cut off by it are not characterized by a radial arrangement. After four to eight rows of cork cells are formed, the activity of more deeply seated meristematic layers results in the formation of successive cork cylinders (Plate VI, fig. 5).

I am glad to have this opportunity of expressing my thanks to Dr. H. D. Gordon, who suggested the examination of this Tasmanian genus, and to the Committee of the Biological Survey of Tasmania who defrayed the cost of collecting the material. The problem arose during the course of investigations carried out whilst in receipt of a Commonwealth Research Grant.

#### REFERENCES

- HOOKE, J. D., 1860.—*The Botany of the Antarctic Voyage*, Part III, Vol. 1, London.  
 RODWAY, L., 1903.—*The Tasmanian Flora*, Hobart.  
 SOLEREDER, H., 1908.—*Systematic Botany of the Dicotyledons*, Oxford.

#### PLATE VI

FIGURE 1.—Leafy stem of *Richea sprengelioides*. Nat. size.

FIGURE 2.—T.S. of stem of *R. dracophylla*, showing crystal sacs in the pith.  
 CS crystal sac.  
 C crystal of calcium oxalate.

FIGURE 3.—L.S. of stem of *R. dracophylla*, showing crystal sac in pith.

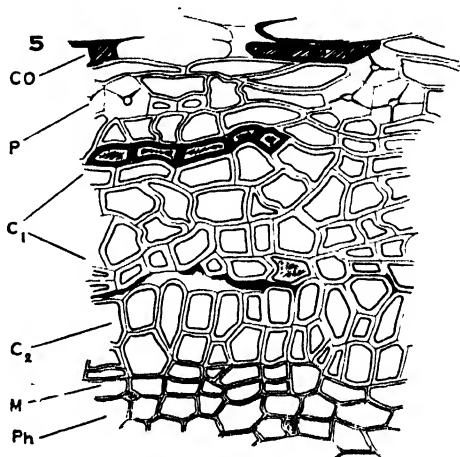
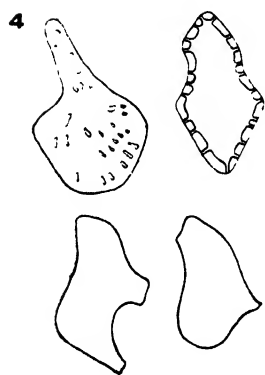
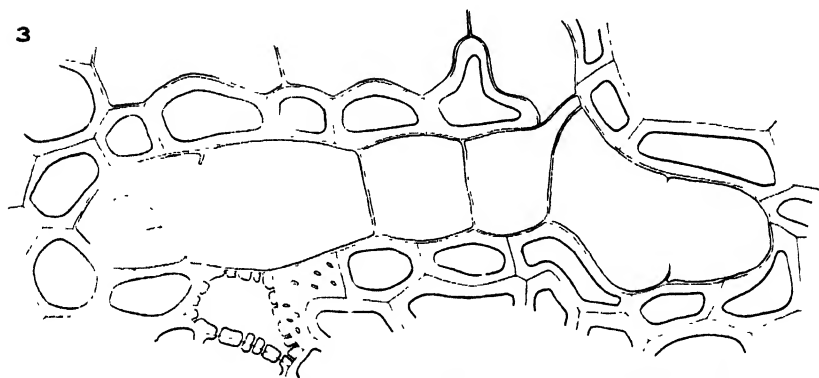
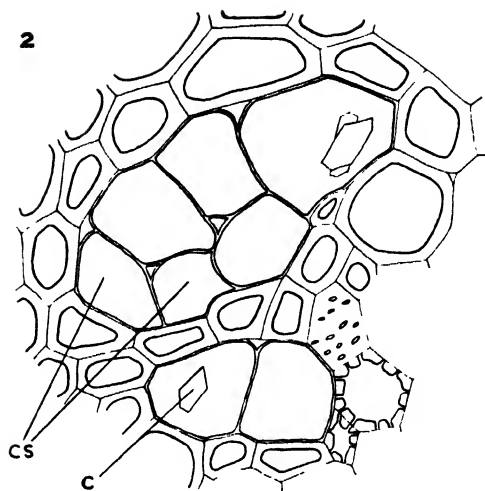
FIGURE 4.—*R. dracophylla*. Cells of ground tissue of pith, isolated by maceration.

Figs. 1-4 made with camera lucida, X 162.

The pitting of the cells of the ground tissue is shown in two cells only in each diagram.

FIGURE 5.—*R. procera* T.S. of stem showing formation of cork.  
 Drawn with camera lucida, X 312.

co cortex  
 p pericycle  
 c<sub>1</sub> first zone of cork  
 c<sub>2</sub> second zone of cork  
 m meristematic layer  
 ph phloem





## The Morphology of *Tettigarcta tomentosa* White, (Homoptera, Cicadidae) <sup>(1)</sup>

By

J. W. EVANS, M.A., D.Sc., F.R.E.S.

(Read 11th November, 1940)

For a long time great interest has been shown in Australian cicadas belonging to the genus *Tettigarcta* White. This is because of certain primitive features of their structure and their wide divergence from all the rest of the Cicadidae. In spite of this interest their detailed morphology is largely unknown, and only a few specimens are to be found in the museums of the world.

In 1937 a biological survey of the fauna of Tasmania was initiated, and collectors in country districts were asked to keep a special watch for the 'Hairy Cicada'. As a result a few specimens were acquired in 1939, and in the following year nearly fifty specimens were procured, all from one locality. The present study is concerned with those features of the morphology of *Tettigarcta* that are of especial interest from the standpoint of comparative morphology.

### NOMENCLATURE AND SYSTEMATIC POSITION

The genus *Tettigarcta* and the genotype *Tettigarcta tomentosa* were described by Adam White (1845) in an appendix to 'Eyre's Expeditions and Discoveries in Central Australia.' Excellent figures of an immature and adult insect accompanied the descriptions, but the only locality recorded was 'Australia'. In the following year, White (1846) re-described in almost identical words, both the genus and the species, on this occasion giving the locality as 'Australia, near Melbourne'.

Many years later Distant (1883) described a second species in the genus, which he named *Tettigarcta crinita*. *T. crinita* differs from the genotype in having the lateral angles of the pronotum rounded instead of pointed. Distant was not aware from what part of Australia his specimen originated. Froggatt in 1903 described a specimen of *T. tomentosa* which he had received from Tasmania, and in the following year with Goding (Goding and Froggatt, 1904) re-described the genus and both species. These authors were of the opinion that *tomentosa* was confined to Tasmania and *crinita* limited to Victoria. Ashton (1924) later extended the range of *crinita* to Mt. Kosciusko in New South Wales. Since the genotype is, as may be seen from the original illustration, clearly the Tasmanian species, and as Eyre did not visit Tasmania, one is forced to the conclusion that White was misled as to the place of origin of the specimens he described.

(<sup>1</sup>) Published under the auspices of the Tasmanian Biological Survey.

Distant (1906) placed the genus in the Division *Tettigarctaria* of the sub-family *Tibicinae*. Myers (1929), however, rightly considered it merited sub-family rank and accordingly created the sub-family *Tettigarctinae* for its sole reception.

#### DESCRIPTION AND HABITS

Both species are medium-sized, dull or reddish-brown cicadas, with a wing expanse of about three inches. *T. crinita* is slightly larger than the genotype. The fore-wings are suffused with pale brown or reddish-brown and the distal divisions of the veins may be surrounded by dark-brown markings. The most striking superficial characteristics are the extreme hairiness of the body and the small head in relation to the very large pronotum.

Although these cicadas are especially associated with high altitudes, they have also been taken close to sea-level. Ashton caught several specimens of *T. crinita* in February (summer) on Mt. Kosciusko at a height of 5000 feet. Most of the specimens of *T. tomentosa* received by the Tasmanian Biological Survey were from Tarraleah, which is at an altitude of 2500 feet. These were obtained during May and June (winter), being attracted to lights even on cold frosty nights; a few were seen flying at dusk. During the day they shelter under bark. Emergence from nymphal exuviae takes place at night and insects have often been seen early in the morning with their wings not fully developed. With other cicadas it is also usual for transformation from nymphs to adults to occur during night-time.

#### MORPHOLOGY (*T. tomentosa*)

##### The Head

The morphology of the head of cicadas has been dealt with fully by Myers (1928). The present author's interpretation of homopterous head-structure differs from that of Myers in several respects and has been given in an earlier paper, (Evans, 1939).

Fig. 1 represents the head of a mature nymph in lateral aspect. The antennae have nine segments, which is more than possessed by other cicadas. Attention is directed to the attachment of the labium anteriorly to the head just behind the maxillary plates and posteriorly to the floor of the prothorax. The sternal apophyses of the prothorax are shown in the figure.

Fig. 2 illustrates the head of a nymph viewed from behind. The eyes and vertex have been removed, also the maxillary plate and its stylet and apodeme, and the apodeme of the hypopharynx from the right hand side revealing the attachment of the mandible to the inturned margin of the lorum. The adult head (fig. 3) differs from that of the nymph in the reduction of the number of antennal segments to four and the flattening of the clypeus. It remains long and narrow and does not become wide as is usual in cicadas. The labium also remains long and reaches to beyond the hind coxae.

##### The Thorax

The head and thorax of *T. tomentosa* in dorsal aspect are illustrated in fig. 4. The only part of the pronotum to which muscles are attached is the anterior third immediately behind the eyes; the rest freely overlaps the mesonotum. Myers states that the hypertrophied pronotum of *Tettigarcta* overshadows the much reduced mesonotum. Actually the mesonotum is in no way reduced, only concealed, and the condition in *Tettigarcta* resembles that usual in Homoptera apart from the Cicadidae, where the only part of the thorax that is visible dorsally is the pronotum and the triangular scutellum of the mesonotum.

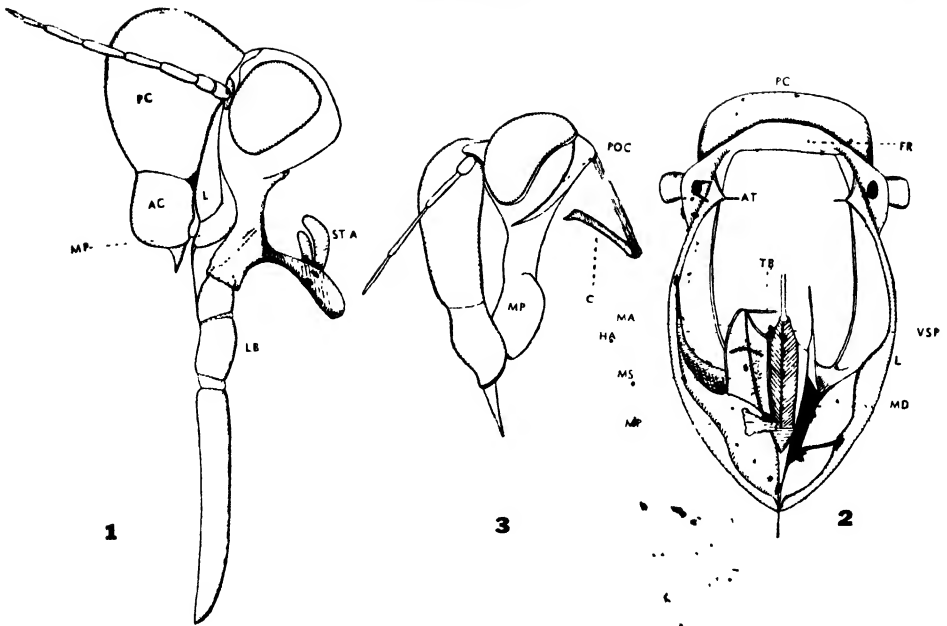
*Tettigarcta tomentosa*

FIG. 1.—Head of nymph in profile. pc, post-clypeus; ac, ante-clypeus; l, lorum; mp, maxillary plate; lb, labium; sta, sternal apophyses.

FIG. 2.—Head of nymph from behind after the removal of the vertex and the eyes, the maxillary plate and its attachment have also been removed from one side. fr, frons; at, at base of anterior tentorial arms; tb, body of the tentorium; ma, maxillary apodeme; ha, hypopharyngeal apodeme; ms, maxillary stylet; md, mandibular stylet; vsp, ventral surface of the sucking-pump. Other lettering as in Fig. 1.

FIG. 3.—Head of adult in profile. poc, postoccipital suture; cs, cervical sclerite. Other lettering as in Fig. 1.

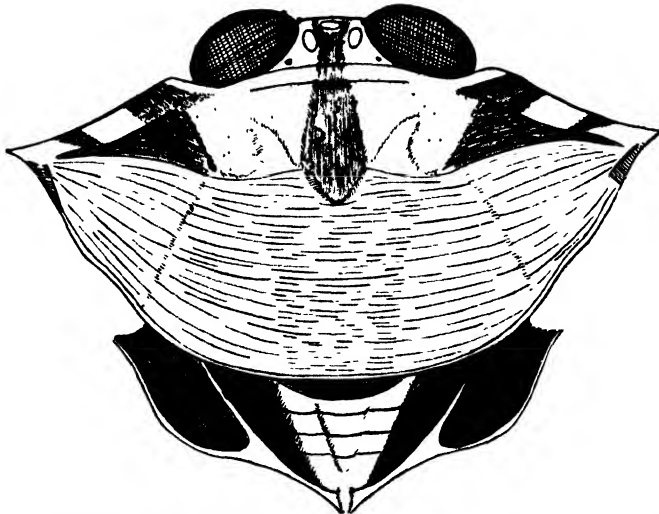


FIG. 4.—*Tettigarcta tomentosa*. Head, pronotum and scutellum in dorsal aspect.



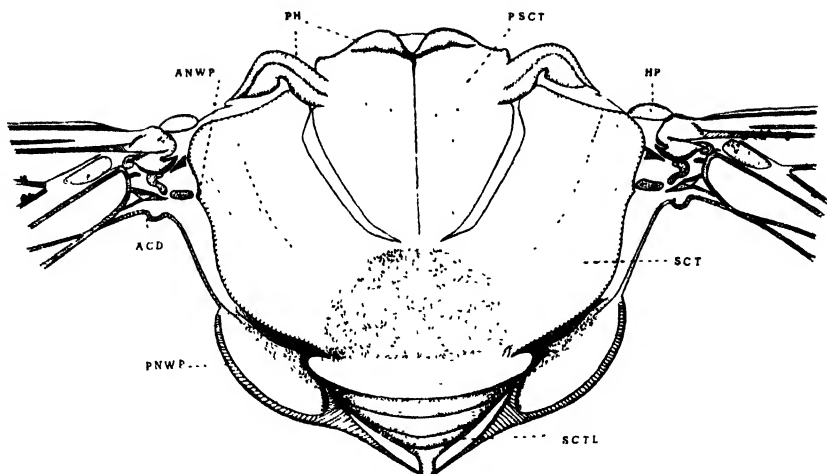


FIG. 5.—*Tettigarcta tomentosa*. Mesonotum and axillary sclerites of the forewing after removal of the pronotum. ph., phragma. psct., prescutum. anwp., anterior notal wing process; hp., humeral plate; pnwp., posterior notal wing process; scl., scutum; sctl., scutellum; acd., axillary cord.

If the pronotum is removed the mesonotum is disclosed, (fig. 5). I am doubtful as to the exact limits of the prescutum. Apart from the apical scutellum, the mesonotum is divided into two parts by wide sutures. These sutures separate the attachments of the median dorsal longitudinal muscles and the tergo-sternal muscles of the fore-wings. Both Myers and Beamer (1928) consider the whole of the central U-shaped area to be the prescutum. Snodgrass defines the prescutum as a narrow transverse strip behind the antecostal suture which may end in pre-alar bridges. Imms (1925) figures the mesotergum of a tipulid, and labels the large anterior area 'prescutum', whilst Rees and Ferris (1939) name the same area in another tipulid 'scutum'.

It is suggested that the narrow anterior thickening of the notum, labelled 'phragma' in fig. 5, is the acrotergite and that the bent lateral ridges, also labelled 'phragma', are pre-alar bridges. These are fused ventrally with the anepisterna of the mesopleuron on each side. The prescutum is then an area behind the acrotergite, between the pre-alar bridges, and is not defined posteriorly; most of the centre of the U belongs to the scutum. The posterior median area of the scutum (shaded in the figure) is depressed and the scutellum is raised and narrows apically. The latter completely conceals medially, not only the metanotum, but also the first and second abdominal segments. From the re-curved apex of the scutellum a large vertical phragma descends; to it are attached the median dorsal longitudinal muscles of the fore-wings. The metanotum, which is reduced, is not figured. The pleural and sternal surfaces of the thorax of a mature nymph are illustrated in figs. 6 and 7. Recent work by Ferris (1940) has added considerably to the comprehension of the structure of the insect thorax, and Ferris' interpretation has been adopted in the present paper.

In fig. 7 the thorax has been cut dorsally and the severed sides flattened out. In the prothorax the sternal apophyses arise from separate pits and are free distally. The pleural apodeme is short, wide, and strong, and bears a long narrow apophysis. The mesothorax retains its primitive structure to a greater extent

than the rest of the thorax. Both the episternum and epimeron are undivided, a trochantin is present, and a meron separated off from the base of the coxa. The sternal apophyses arise from separate pits at the posterior apex of a triangular sclerotized area, the true sternite. In the metathorax the sternal apophyses arise from a single pit.

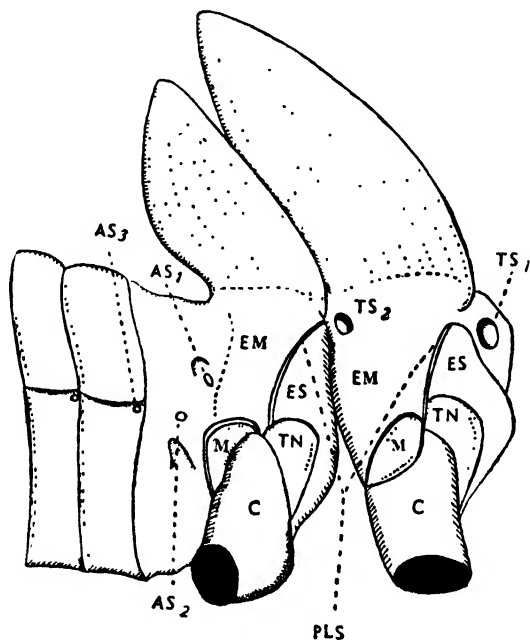
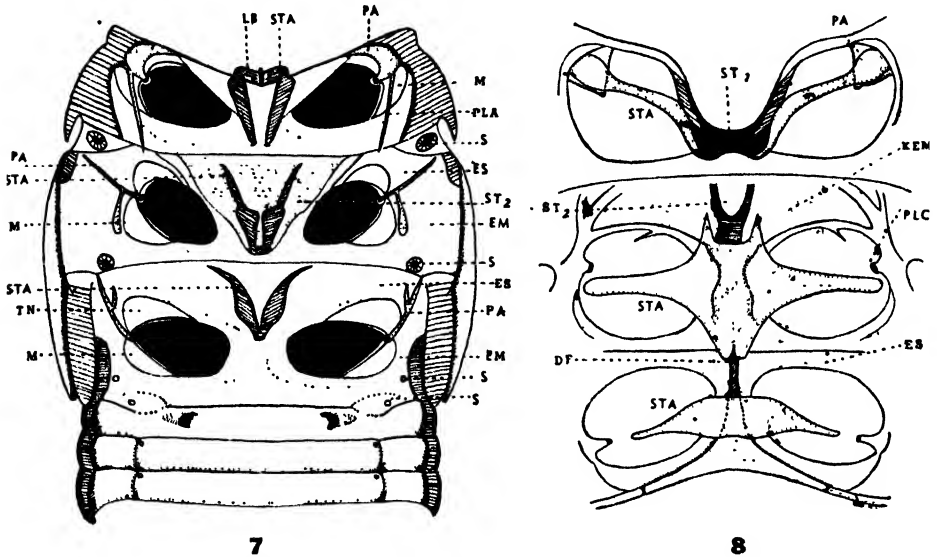


FIG. 6—*Tettigarcta tomentosa*. Lateral aspect of the meso- and metathorax and anterior four abdominal segments of a nymph; the wing pads are folded back. ts., thoracic spiracle; es., episternum; em., epimeron; tn., trochantin; m., meron; c., coxa; pls., pleural suture; as., abdominal spiracle.

The structure of the thorax of an adult insect is shown in figs. 8, 9, 14, and 15. The sternal apophyses of the prothorax are fused to the anterior lateral margins of the leg-cavities and the pleural apodemes on each side. The sclerotized area between the apophyses is labelled 'Sternum 1', but it is uncertain whether it contains any elements of the true sternum. In the mesothorax the episternum is divided into an anepisternum, a katepisternum and a pre-episternum. The pre-episterna of the two sides meet mid-ventrally at the discriminal line, leaving anteriorly a small triangular area, the remnant of the sternite of the nymph. Ferris has defined the discriminal line as the line of meeting mid-ventrally of the sub-coxal elements of the two sides of the body. The large sternal apophyses of the mesothorax arise from the posterior continuation of the discriminal fold; they are free apically. Myers recognises and figures a separate 'median division of the episternum' of the mesothorax in cicadas. In *Tettigarcta* there is a partial division of the episternum into three parts, laterally by a cleft or suture and medially by a furrow with an internal ridge. Neither completely divides the sclerite, and it is believed that both are secondary developments. The epimeron is divided into an anepimeron and katepimeron. In the metathorax the episternum

is undivided and the episterna of the two sides meet mid-ventrally at the discriminal furrow. The epimeron consists of an anepimeron and katepimeron and a narrow post-coxal sclerite is articulated with the posterior ventral prolongation of the latter.



*Tettigarcta tomentosa*

FIG. 7.—Thorax and anterior abdominal segments from above, internal aspect. pa., pleural apodeme; pla, apophysis of pleural apodeme. s., spiracle; st., sternum; other lettering as in previous figures.

FIG. 8.—Internal ventral view of the adult thorax to show sternal apophyses. df., discriminal fold; plc., pleural condyle, other lettering as in previous figures.

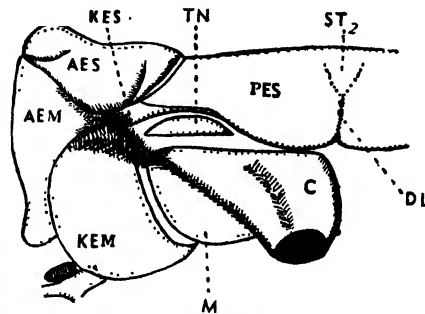


FIG. 9.—*Tettigarcta tomentosa*. Left pleuron and coxa of adult mesothorax. aes., anepisternum; kes., katepisternum; pes., pre-episternum; aem., anepimeron; kem., katepimeron; dl., discriminal line. Other lettering as in previous figures.

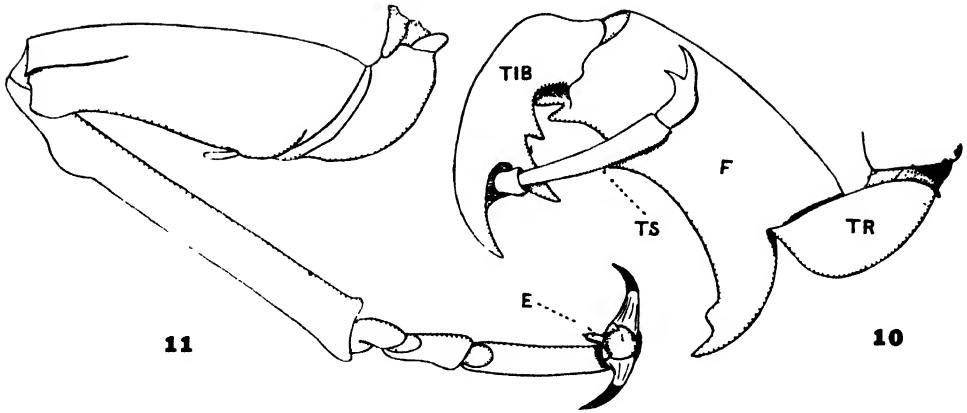
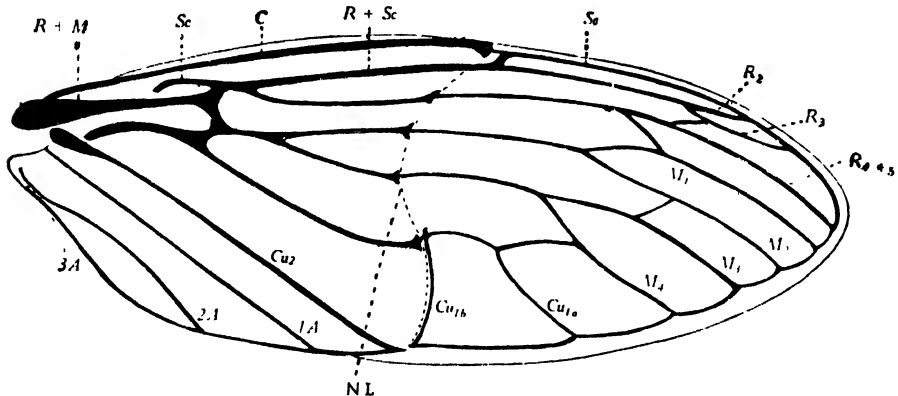
*Tettigarcta tomentosa*

FIG. 10.—Foreleg of nymph. ts., tarsus; th., tibia; f., femur; tr., trochanter.

FIG. 11.—Foreleg of adult e., empodium.

### The Legs

The fore-leg of a mature nymph and of an adult insect are figured (figs. 10 and 11). The tarsus of the nymph has two segments and the claws, which are of different sizes, are fused basally. In the adult leg the femur is not so broad as is usual with cicadas and bears a single finger-shaped process. All three pairs of legs are remarkably long and empodia are present.

FIG. 12.—*Tettigarcta tomentosa*. Forewing

### The Wings

The wings are steeply tectiform and meet close behind the apex of the scutellum when at rest. The forewings are wrinkled and coriaceous and lack cross-ridgings; the veins are hairy. The venation is of extreme interest. In the fore-wing (fig. 12) the costal vein lies a little below the anterior margin; it is preceded in the nymph by a strong vein containing a trachea. There is a considerable space in the nymphal wing-flap between the costal vein and a group of three trachea that lie below it. The upper of these represents the sub-costal vein. This vein in the adult is convex on the lower surface of the wing proximally, thence it appears on

the upper surface, and is fused with the upper branch of the radial sector as far as the nodal line. From this point it lies just inside the margin of the wing and appears to be continuous with the costal vein. The upward turn of the sub-costal trachea at the nodal line can be seen clearly in the nymph. Accepting Comstock's (1918) statement that  $R_1$  is not present in the Cicadidae, the trachea that immediately adjoins  $Sc$  and divides into two well before the nodal line, must represent the radial sector, the upper branch of which, as has already been stated, is fused for part of its length with the sub-costal vein in the adult wing. All four branches of the median vein are developed, and there is a third anal vein. The nodal line consists of a line of weakness that extends across the wing in the position shown. Where the veins cross the line they break and appear re-joined on the ball and socket principle. The significance of the line is discussed in a later section.

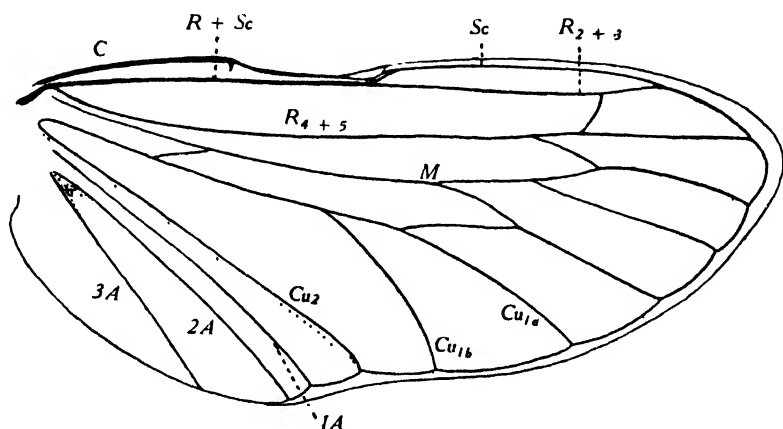


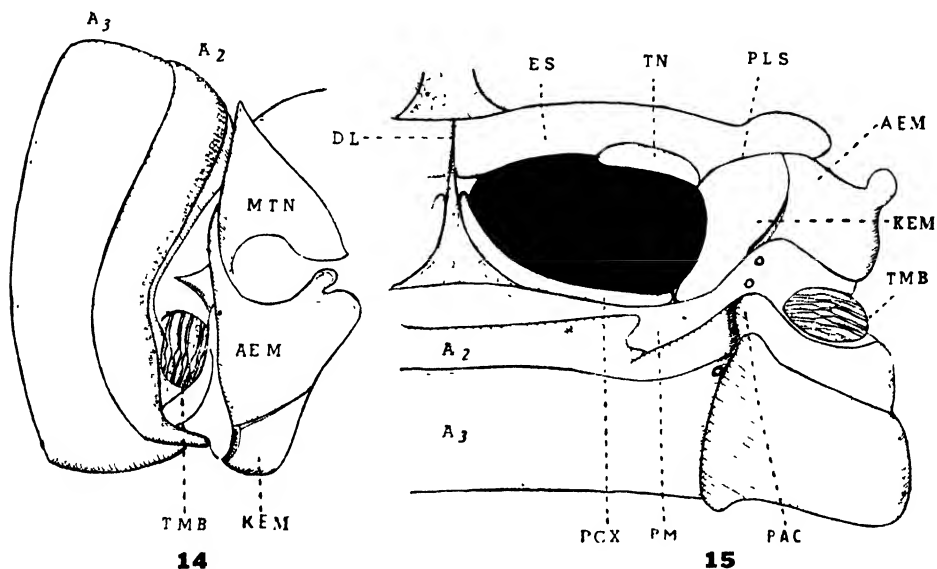
FIG 13.—*Tettigarcta tomentosa*. Hindwing.

The hind-wing (fig. 13) is pale brown with small hairs on the membrane and slightly longer hairs on the veins. As in the case of the fore-wing, there is in the nymphal wing pad a costal vein and trachea separated by a wide space from a group of three tracheae. The first of these tracheae precedes the sub-costa, and in the adult wing the corresponding vein is fused for its proximal half with the upper branch of the radial sector. Distally it lies close to the fore-border of the wing, but is not joined to the costal vein, being separated from it by the overfolded marginal wing-catch. The second branch of the radial sector meets the other branch close to the base of the wing; this feature and the fusion of  $M_1$  and  $M_2$  into a single vein are the principal characters in which the venation of the hind-wing differs from that of the fore-wing.

### The Auditory and Sound-Producing Organs

There is no trace of auditory organs in either sex of *Tettigarcta*. In other cicadas the mirrors or auditory tympana are part of the first abdominal sternite and the auditory capsule part of the second tergite. The positions these organs would occupy if present are indicated in fig. 15. Myers records finding a slight swelling on the ventral lateral angle of the second tergite, but states that there is no external evidence that it is an auditory capsule. There is also no internal evidence on this point.

With respect to sound-producing organs, Tillyard (1926) mentions that the males have no vestiges of such organs, but Myers noticed that the 'first abdominal segment of *Tettigarcta* is greatly reduced and shows laterally a slightly swollen area, free from the long hairs that thickly clothe the rest of this region and furnished with faint ridges'. He continues 'Were not nearly all the other characters of *Tettigarcta* apparently highly primitive, one would be inclined to see in this structure the last vestiges of tymbals lost in the history of the race'.



*Tettigarcta tomentosa*

FIG. 14.—Lateral view of part of thorax and abdomen. mt. n., metanotum, tmb., tymbal, a., abdominal segment. Other lettering as in previous figures.

FIG. 15.—Ventral view of part of metathorax and abdomen. pcx., postcoxale, pm., position of mirror, pac., position of auditory capsule. Other lettering as in previous figures.

Myers was correct in recognizing these swollen areas as tymbals. They lie on each side of the body in the position indicated in figs. 14, 15, and 16, and form part of the first abdominal tergite. Their surface is smooth and marked with a pattern of white stripes on a pale-brown background. The tymbals are not functional and the stripes are homologous with the ridges of fully-developed tymbals. A bundle of muscle fibres is attached directly to the inner surface of each tymbal. These muscles are attached ventrally to a narrow sclerotized plate that lies in the membrane of the first abdominal sternite. Tymbals are equally well developed in both sexes, but the tymbal muscles of the male are stronger than those of the female, though not so large as the huge tymbal muscles of other cicadas. The narrow transverse sclerotized plate from which the muscles arise is homologous with the abdominal furca of cicadas of various authors. Myers correctly stated that the furca was not an endoskeletal structure, but a differentiated anterior part of the first abdominal sternite. The first pair of abdominal spiracles lie close to the apices of this plate.

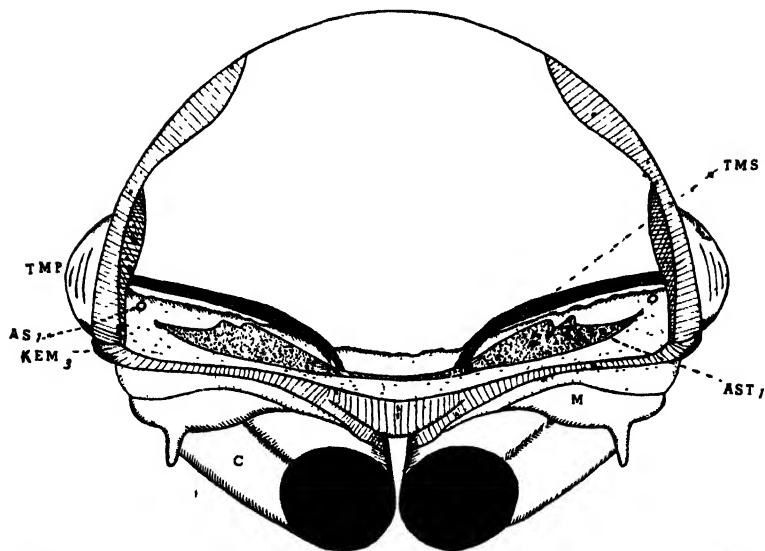


FIG. 16.—*Tettigarcta tomentosa*. Transverse view of part of metathorax and part of first abdominal sternite from behind. ast., sclerotized plate of first abdominal sternite.

### The Alimentary Canal

The alimentary canal is illustrated in fig. 17. It resembles in essentials those of other cicadas as described by Myers. The filter chamber into which the oesophagus opens comprises the first ventricle of the stomach (Snodgrass, 1935), and part of the third ventricle, labelled 'mid-intestine' in the figure. The mesenteric sac is the second ventricle. In several fresh specimens of *Tettigarcta* that were examined, the mesenteric sac was found as a small, very wrinkled, and folded sac. In others, including some that had only recently abandoned their nymphal exuviae, it consisted of a thin smoothed-walled sac, distended with air, which occupied fully three-quarters of the abdominal cavity. The remaining quarter contained gonads and fat-body. Such a condition has also been recorded in leaf-hoppers (Evans, 1931).

### The Tracheal System

The chief point of interest in the tracheal system lies in the alleged presence of a large tracheal air sac. Snodgrass is of the opinion that most of the abdominal cavity of the cicada *Magicicada septendecim* is occupied by a huge tracheal air chamber that opens directly to the exterior, through the first abdominal spiracles, and has tracheal tubes issuing from its walls. Myers claims that the sac is merely the distended mesenteric sac or second stomach ventricle of the alimentary canal. He was, however, able to trace a trachea from the first abdominal spiracle which, without penetrating the mesenteric sac, formed a tracheal knot on its surface from which tracheae ramified over the wall of the sac.

In *Tettigarcta* it is quite certain that there is no trace of any development of a tracheal air sac. In fig. 17 a trachea is shown which originates from the first abdominal spiracle of the right-hand side. This trachea breaks up into several smaller tracheae, but does not form a tracheal knot such as is described and illustrated by Myers. As, even in freshly-emerged cicadas, the mesenteric sac may fill the greater part of the body cavity, and must therefore become distended further in older insects in which fat-body is reduced, Myers' interpretation would appear to be

correct, in spite of the fact that Snodgrass (1935) gives a figure (fig. 237, p. 449) showing both the second ventricle of the stomach and an air sac in the same insect. The whole body cavity of *Tettigarcta* contains countless small air sacs, the mesenteric sac being especially well supplied with these, two of which are shown in the fig. 17.

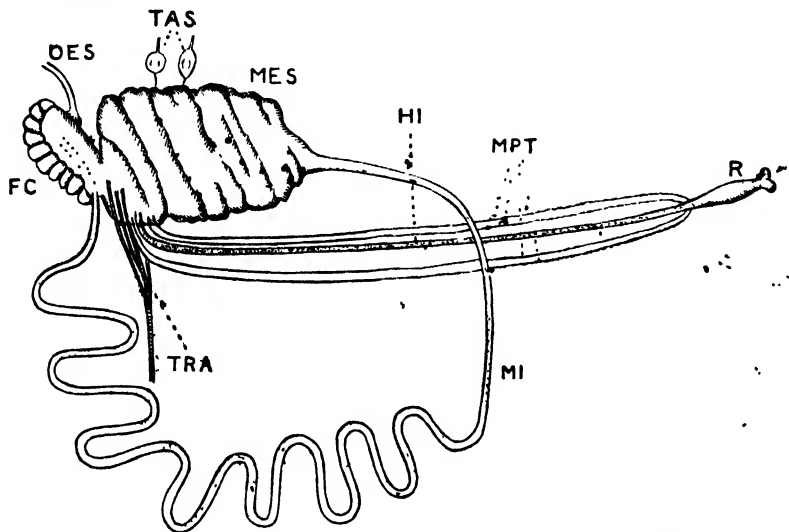


FIG 17.—*Tettigarcta tomentosa*. Alimentary canal. fc., filter chamber. oes., oesophagus; mc., mid-intestine, hi., hind-intestine. mes., mesenteric sac; mpt., malpighian tubules; tra., trachea; tas., tracheal air sacs, r., rectum

The anterior spiracles of the nymph are shown in figs. 6 and 7. The two large thoracic spiracles, which are closed by flaps, both occur in the mesothorax. There are eight abdominal spiracles. The two first of these have migrated forward, the anterior lying between the thorax and the segmented portion of the abdomen, the posterior just in front of the margin of the segment to which it belongs. Vogel (1923) believed that communicating longitudinal and transverse tracheae are absent in cicadas. This point has not been investigated, but Myers' statement 'that all the spiracles, without exception, are linked up by a longitudinal trunk on each side, is obvious from an examination of a nymphal exuviae' is open to question. Although superficial examination of a nymphal exuviae would certainly support this view, further investigation discloses that each trachea is distinct from its neighbour, and there is no trace of longitudinal trunks.

### The Male Genitalia

The sternum of the eighth segment is produced posteriorly into a more or less flattened rectangular flap that underlies the ninth segment. The ninth segment is narrow dorsally and wide ventrally; from it arise the aedeagus, the prolongation of the fused basal plates and a pair of parameres (fig. 18). The aedeagus seen from above is trough-shaped, the trough forming a basin-like depression at its proximal end. The apex of the aedeagus consists of a fleshy pad with an outer border of large flattened wide-based spines, and an inner border of small inwardly-turned flat spines. Attached to the proximal end of this pad is a tongue-shaped process which serves to close the opening of the ejaculatory duct. The aedeagus is hinged basally with the basal plates; these plates are fused



together and produced into a boat-shaped structure that supports the aedeagus ventrally. The parameres, harpogones, or genital styles of the two sides are joined to each other by a set of transverse muscles, and have also other lateral muscles that are attached to the wall of the ninth segment. Lying immediately below the basal plates is a fleshy pad with an invaginated apodeme. Strong muscles that arise from this apodeme are joined to the posterior up-turned sides of the genital segment. The tenth segment is membranous and concave ventrally, and is separated into a pair of up-turned and in-turned flaps apically. The eleventh segment is ring-like and from it arises the anal segment.

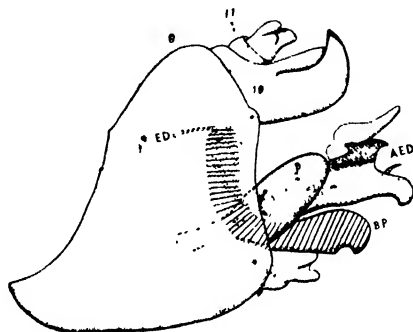


FIG 18—*Tettigarcta tomentosa*. Male genitalia. ed., ejaculatory duct; p., paramere; aed., aedeagus; bp., basal plates.

### DISCUSSION

The present distribution of *Tettigarcta*, which is confined largely to high altitudes in south-eastern Australia and Tasmania, suggests that it forms one of the components of the cold-climate fauna that was dominant in these regions for periods both in mid and late Tertiary times. It is suggested that *Tettigarcta tomentosa* has retained a climatic rhythm which it acquired during a glacial epoch, since early winter temperatures that prevail between two and three thousand feet in Tasmania at the present day, may well be comparable to those that prevailed at sea-level during the short summer months of a period of intense cold. Further, it is believed that the habit of subterranean existence shared by the nymphs of all cicadas was originally developed as a response to cold climatic conditions.

Both species of *Tettigarcta* differ from all other recent cicadas in the following characters:

The nymphs have nine antennal segments, which is a greater number than that possessed by other cicadas.

The spiracles of the nymphs are not concealed by pleural flaps.

The adult is densely pilose and has an unusually small, narrow head in relation to the pronotum.

The pronotum has very large posterior and lateral expansions which conceal the scutum of the mesonotum.

The mesonotum has a well-developed scutellum that narrows apically and entirely conceals the metanotum.

The fore-wings are without cross-ridgings. The principal veins are evenly distributed and not massed against the fore-border.

The venation is remarkably complete and a nodal line is fully developed.

A separate costal vein is retained in the hind-wing.

The fore-femora are not markedly swollen, empodia are present, and all the legs are longer in relation to the body than is usual in the family.

Auditory organs are absent in both sexes.

Non-functional, but fully developed, sound-producing organs are present in both sexes.

The male genitalia have a true aedeagus, an unusual development of the basal plates, and harpogones are present.

It is proposed to discuss briefly the significance of only two of these characters, the sound organs and the nodal line. With regard to the sound organs, one can assume that the development of these was contemporaneous with, or slightly in advance of, the development of auditory organs. *Tettigarcta* has no trace of auditory organs in either sex, but has tymbals in both sexes, and only slightly less development of tymbal muscles in the female than in the male. Therefore one can reasonably conjecture that it is descended from an early cicadan stock that possessed in both sexes well-developed sound-producing organs and also sound-detecting organs. It is probable that neither set of organs was so complex or efficient as those found in present-day cicadas. For some reason, possibly associated with its nocturnal habits and cold climate environment, for modern cicadas are essentially sun-loving creatures, *Tettigarcta* ceased to be vocal. The sound-organs later lost their power to function and the auditory tympana, which were probably of a rudimentary nature reverted to undifferentiated parts of the segmental membrane of the first abdominal segment. It has been found that the membrane of this segment where it is adjacent to the break and curvature of the second abdominal sternite (fig. 15) is slightly denser than and of a different consistency from the rest of the segment.

Sound production in insects has arisen independently in many groups, and it can be assumed that in all instances it has commenced by simple methods, the actual organs involved never being specially designed for such a purpose. The rubbing of two adjacent parts of the thorax, or of legs together, or of legs against elytra, being the usual initial development. With cicadas, the position would appear to differ, as there is no rubbing action, but part of the dorsal surface of the first abdominal segment is differentiated into a complex tymbal, to which are attached strong tymbal muscles. If any evidence could be obtained to suggest that sound production was originally effected by the pull of certain muscles on to undifferentiated areas of the dorsal surface of the first abdominal segment, then the mystery of the origin of cicada song would be solved.

An examination has been made of the muscle system in the region of the base of the abdomen in *Eurymela fenestrata* Le P. & S.: This is a leaf-hopper, chosen on account of its large size and because preserved material was available. When the greater part of the abdominal segments is removed and the fat-body cleared away, the most noticeable structures are two very large columnar bands of muscles. These arise independently from near the mid-ventral line of a sclerotized ridge situated transversely in the membrane of the ventral surface of the first abdominal segment. These muscle bands are almost vertical, but directed somewhat laterally. They are attached dorsally to the hind margin of the metanotum. Each band is divided mid-way by a transverse circular sclerotized plate. The function of these muscles is unknown, but it needs no great flight of imagination to suppose that their dorsal attachments may have for some reason migrated for a short distance posteriorly. They would thus cease to be intersegmental muscles and become confined to the first abdominal segment. The membrane of this segment is strengthened dorso-laterally by two crescentic bars that form the hind margins of ovals. Part of the

hind border of the metanotum on each side bounds the ovals anteriorly. It is in a corresponding position to the membranous centres of these ovals that the tymbals of *Tettigarcta* are situated. One can conjecture that the gradual backward migration of the muscles resulted in a thickening of the abdominal wall, and that as a result of this thickening slight sound production became possible. The homologous muscles in *Eurymela* resemble much more, both in size and position, the tymbal muscles of modern male cicadas than those of *Tettigarcta*.

The significance of the nodal line has been fully discussed by Myers and earlier authors. It has already been pointed out that it consists of an irregular transverse line of weakness in the fore-wings of *Tettigarcta*. It is also developed to a varying, but less extent, in all other cicadas. Tillyard believed it to represent the beginnings of the division of the wing into a corium and membrane such as occurs in the Heteroptera. Imhof (1905) was of the opinion that it had some relation to the mechanics of flight.

The hemielytral condition of the fore-wings of Heteroptera is directly associated with the apical overlap of the fore-wings when they are at rest. No Homoptera, except certain Fulgoroids (Achilidae), have strongly overlapping fore-wings; they are either steeply tectiform or somewhat flattened, but distinct. The fact that the nodal line persists to such a degree in all cicadas, and that similar breaks in wings occurred in certain Mesozoic Homoptera,\* would seem to favour Imhof's interpretation, especially as the wing is readily bent along the line in living specimens of *Tettigarcta*, more especially those that have only recently acquired fully-developed wings. It is further believed that the nodal line is only a parallel development with the condition that occurs in the Heteroptera and that it does not necessarily denote a common origin of the two groups or even a similar evolutionary trend.

#### REFERENCES

- ASHTON, H., 1924.—Notes on the Hairy Cicada. *Proc. Roy. Soc. Vic.* 36; 238.  
 BEAMER, R. H., 1928.—Studies on the Biology of Kansas Cicadidae. *Bull. Univ. of Kansas* 29 (7); 55.  
 COMSTOCK, J. H., 1918.—*The Wings of Insects*, Comstock Publishing Co., N.Y.  
 DISTANT, W. L., 1883.—Contributions to a proposed Monograph of the Cicadidae. *Proc. Zool. Soc. London*, 188.  
 ———, 1905.—A Synonymic Catalogue of the Homoptera, Pt. 1 Cicadidae. London British Museum.  
 EVANS, J. W., 1931.—The Biology and Morphology of the Eurymelinae. *Proc. Linn. Soc. N.S.W.* 56 (3); 210.  
 ———, 1939.—The Morphology of the Head of Homoptera. *Pap. Roy. Soc. Tasm.*, 1938 (1939); 1.  
 FERRIS, G. F., 1940.—The Myth of the Thoracic Sternites in Insects. *Microentomology* 5 (4); 87.  
 FROGGATT, W. W., 1903.—Cicadas and their habits. *Agric. Gazette N.S.W.* 14; 420.  
 GODING, F. W. AND FROGGATT, W. W., 1904.—Monograph of the Australian Cicadidae. *Proc. Linn. Soc. N.S.W.* 29; 561.  
 IMMS, A. D., 1925.—*A General Textbook of Entomology*. Methuen & Co. London.  
 IMHOF, O., 1905.—Zur Kenntnis des Baues der Insektenflügel insbesondere bei Cicaden. *Zeitschr. wiss. Zool.* 83; 211.  
 MARTYNOV, A. B., 1928.—The Morphology and Systematic Position of the Palaeontinidae. *Yearbook Russ. Palaeont. Soc.* 9; 93.

\* e.g. *Pseudocossos zemczukovi* Martynov, Family Palaeontinidae, (Martynov, 1928).

- MYERS, J. G., 1928.—The Morphology of the Cicadidae. *Proc. Zool. Soc. London* (2): 365.
- , 1929.—*Insect Singers*. G. Routledge and Sons, London.
- REES, B. E., AND FERRIS, G. F., 1939.—The Morphology of *Tipula reesi*. *Microentomology* 4 (6), 143.
- SNODGRASS, R. E., 1935.—*Principles of Insect Morphology* McGraw Hill Book Co
- TILLYARD, R. J., 1926.—*Insects of Australia and N.Z.* Angus and Robertson Ltd., Sydney.
- VOGEL, R., 1923. Über ein tympanales Sinnesorgan das Mutmassliche Hororgan der Singzikaden.  
*Zeits. ges. Anat.* 67 (1): 190.
- WHITE, A., 1845.—Appendix D in E. J. Eyres *Journals of Expeditions and Discoveries in Central Australia*; 433.
- , 1846.—Descriptions of some Homopterous insects in the collection of the British Museum.  
*Ann. Mag. Nat. Hist.* 17: 332.



A New Genus of Mecoptera from Tasmania (<sup>1</sup>)

By

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(Communicated by J. W. Evans)

(Read 11th November, 1940)

## PLATES VII, VIII

Late in 1939 Dr. J. W. Evans, of the Department of Agriculture, Tasmania, sent me for examination three specimens of a wingless Mecopteron from Mt. Wellington and Mt. Mawson, Tasmania. Since all three insects were females, publication of the description of the species was delayed, with the hope that the male also might be found. This hope was realized in September 1940, when Mr. D. Martin collected a male, as well as another female, on Mt. Mawson. These additional specimens were promptly sent to me by Dr. Evans. The insect turns out to be a very interesting one; it is not only the first record of the family Panorpidae (s.s.) in the Australian region, but it is also the only apterous member of the family known. I am greatly indebted to Dr. Evans for the opportunity of studying this remarkable species.

**Apteropanorpa**, new genus

Both sexes completely apterous, without indications of wing vestiges. Head large, much as in *Panorpa*, with a conspicuous rostrum, fully as large as that in *P. conigera* McL.; eyes small, only slightly protruding; ocelli absent; antennae elongate, with about 60 segments; clypeus broad, more remote from antennal insertions than in *Panorpa*; subgenal suture weak, subgenal processes very inconspicuous; labium long; mandibles toothed as in other Panorpid; maxillary palpi long, similar to those in *Panorpodes*; labial palpi small; thoracic nota contiguous, forming a heavy dorsal shield; 1st abdominal tergite fused with the metanotum; legs slender, typically panorpid, with smooth tarsal claws; abdomen very large and bulbous, with minute dorsal and ventral sclerites. *Female* abdomen: 9th abdominal sternite divided, forming two elongate plates, much as in *Panorpodes*; 10th abdominal sternite apparently absent (or very lightly sclerotized); 11th reduced to a small median plate; cerci long. There is apparently no internal skeleton (vulvar retractor apodeme) in the 9th abdominal segment. *Male* abdomen: tergites 2-6 small; tergites 7 and 8 coalesced with their sternites, forming a ring around the abdomen; 7th and 8th abdominal segments very short; 9th and 10th

(<sup>1</sup>) Published under the auspices of the Tasmanian Biological Survey.

essentially as in *Panorpa*, forming a bulb which is curved over the 7th and 8th segments. The styles (forceps) <sup>(1)</sup> of the coxopodites of 9th segment are in the form of small, cylindrical processes directed inward and apparently attached to part of the 11th segment. The cerci absent or very minute.

Genotype: *Apteropanorpa tasmanica*, n.sp.

I consider this genus to be more closely related to *Panorpodes* (eastern Asia) than to *Panorpa* or *Neopanorpa*. This is especially well indicated by the structure of the terminal abdominal segments. In *Panorpa* the 9th abdominal sternite of the female is a large median plate, covering all of the ventral surface of the segment; in *Apteropanorpa* and *Panorpodes* the sternite is divided and reduced to a pair of slender plates. In *Panorpa* and *Neopanorpa* the 7th and 8th abdominal segments of the male are elongate, whereas in *Apteropanorpa* and *Panorpodes* they are very short. An even more striking similarity between *Apteropanorpa* and *Panorpodes* is found in the structure of the 6th abdominal segment of the male. In these genera the tergites and sternites of that segment are widely separated by membranous areas; but in *Panorpa* and *Neopanorpa* these tergites and sternites are fused so as to form a cylindrical plate around the entire segment.

The apterous condition of *Apteropanorpa* is the most obvious feature of the genus. The head is also unusual in having small eyes, no ocelli, and inconspicuous subgenal processes.

*Apteropanorpa tasmanica*, n.sp.

(Plates VII, VIII)

Length of body, not including antennae, 5.5-6 mm. Head reddish brown; antennae varying from dark brown to light reddish brown; thorax light yellow-brown above, dark reddish brown laterally; abdomen with dark reddish brown tergites, membranous areas mottled with brown and white; cerci brown. The coloration is essentially the same in all types, except one female paratype from Mt. Mawson, which has some dark brown on the mesonotum. The sternites of the terminal abdominal segments of the female probably include good specific characteristics; their structure is shown in Pl. VIII, fig. 4. The abdominal terminalia of the male are represented in Pl. VIII, figs. 1 and 2; the 9th sternite consists of a median plate, partially divided distally.

Holotype (♂): No. 25462, Museum of Comparative Zoology; collected on snow, on Mt. Mawson (4500 ft. elevation), Mt. Mawson, National Park, Tasmania, September, 1940 (D. Martin).

Allotype: collected on low shrubs (*Richea scoparia* Hook f.) on the summit on Mt. Wellington, Tasmania, May 31, 1939 (V. V. Hickman); in the Museum of Comparative Zoology.

Paratypes: 1♀, same collecting data as allotype; 1♀, Mt. Mawson (4200 ft. elevation), Tasmania, on snow (T. Raphael); both in the Australian Museum, Sydney.—1♀, same collecting data as holotype, in the Museum of Comparative Zoology.

<sup>(1)</sup> For these abdominal structures I have used the terminology proposed by Ferris (*Microentomology*, 4 : 79-108, 1939).

In general appearance the female of this insect closely resembles the members of the family Boreidae, but the absence of the long ovipositor, a characteristic of the latter, eliminates all possibility of confusing it with a Boreid. Because of its wingless condition, determination of the family position of *A. tasmanica* must be made on details of body structure. The presence of the two tarsal claws as well as the structure of the abdominal terminalia excludes it from the Bittacidae; and the well-developed rostrum eliminates it from the Choristidae and Nannochoristidae. It has no characteristics, however, which prevent its inclusion in the family Panorpidae, though, of course, certain features, treated above as generic, have not previously been found in any panorpid. *Apteropanorpa* appears to be a highly specialized derivative of primitive Panorpid stock. It has some characteristics of *Panorpa* and some of *Panorpodes*. The elongate rostrum, for example, is like that of *Panorpa*, whereas the long maxillary palpi, simple claws, and the structure of the terminal abdominal segments are like those of *Panorpodes*. The wingless condition of *Apteropanorpa* is suggestive of *Brachypanorpa* (United States), the females of which are subapterous; but the rostrum in *Brachypanorpa* is even shorter than that of *Panorpodes*.

*Apteropanorpa* also presents a striking combination of general and specific characteristics. Among the former may be listed the nearly undivided 9th sternite; in all other Panorpidae this sternite is either forked or split for most of its length. On the other hand, the modification of the styles (forceps) of the coxopodite of the 9th abdominal segment of the male, and the absence of wings and ocelli are obvious specializations. *A. tasmanica* is especially interesting as a third instance of independent wing loss among Mecoptera, the other two cases being the Californian *Apterobittacus* (Bittacidae) and the Holarctic *Boreus* (Boreidae). Noteworthy in this connexion is the fact that three specimens of *tasmanica* were found on snow, an environment in which the adults of *Boreus* also normally occur.

As mentioned above, *tasmanica* is the first record of the family Panorpidae (s.s.) in the Australian region. Although this family is essentially a Holarctic one, many species have been found in southern India, French Indo-China, and the East Indies.<sup>(\*)</sup> The occurrence of a species of this family in the Australian region is therefore not very surprising; but what is remarkable is that this particular species is apterous, nivicolous, and confined (apparently) to certain mountains in Tasmania.

(\*) Navas has described a Chilean Panorpid (*Panorpa ruizi*), but the collecting data of the unique type are probably incorrect (Rev. Chil. Hist. Nat. 30 : 330, 1926).



PLATE VII.

*Apteropanorpa tanmanica*, n.sp. (female, paratype).

FIG. 1.—Dorsal view.

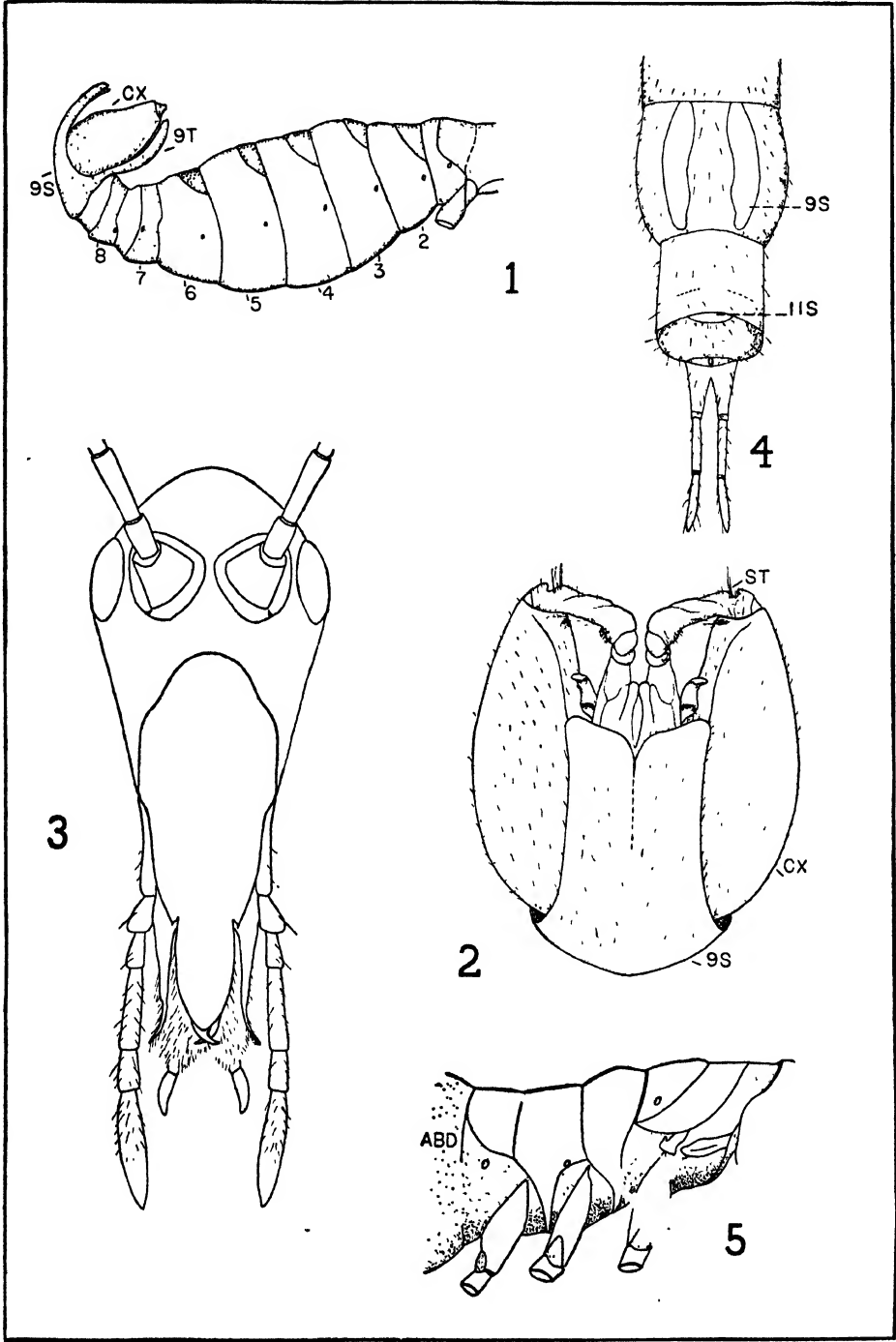
FIG. 2.—Lateral view (only part of the antennae is shown in these photographs)



PLATE VIII.

*Apteropanorpa tasmanica*, n.sp.

- FIG. 1.—Lateral view of abdomen of male (holotype). 2-8 abdominal segments; 9T, 9S, ninth abdominal tergite and sternite; cx., coxopodite of ninth abdominal segment.
- FIG. 2.—Ventral view of male abdominal terminalia.
- FIG. 3.—Front view of head of female.
- FIG. 4.—Ventral view of terminal abdominal segments of female.
- FIG. 5.—Lateral view of thorax of female. 11s., eleventh sternite; ABD., abdomen.





# Observations on the Fishes of the Family Galaxiidae

## Part III

By

E. O. G. SCOTT, B.Sc.

Director, Queen Victoria Museum, Launceston

(Read 11th November, 1940)

### PLATE IX

The present paper records some general observations on *Galaxias* (G.) *truttaceus*, including the discovery of a regular sequence of colour-pattern phases in this species.

*Conventions.* All dimensions are recorded in millimetres: except in a few instances where ambiguity might arise, the unit of measurement is omitted. Length-classes are designated by their mid-points. Abbreviations used include: LS = standard length; LT = total length;  $h$  = width of class-interval;  $f$  with numerical suffix = frequency of length-class specified by suffix;  $\bar{x}$  = arithmetic mean; Md = median; Mo = mode;  $Q_1$ ,  $Q_3$  = 1st, 3rd, quartiles;  $\sigma$  = standard deviation, using  $(n - 1)$ .

### Genus *Galaxias* Cuvier, 1817

*Galaxias* Cuvier, *Règn. Anim.* ed. 1. 11. 1817: 183. Haplotype *Esox truttaceus*

Cuvier, 1817

### *Galaxias* (*Galaxias*) *truttaceus* (Cuvier, 1817)

*Esox truttaceus* Cuvier, *Règn. Anim.* ed. 1. 11. 1817: 184.

*Galaxias ocellatus* McCoy, *Intercol. Exhib. Ess.* 7. 1866: 14.

*Galaxias truttaceus* Regan, *Proc. Zool. Soc. London.* 1905 (1906). II.: 378: pl. XII. fig. 4 (reference).

### MATERIAL AND LOCALITIES

Material examined, comprising upwards of 700 specimens, representing 36 Tasmanian and several extralimital localities, falls conveniently into 5 sections noted below. Letters in brackets refer to map (Text-fig. 1): in series marked with an asterisk *G. (G.) truttaceus* occurs in association with *G. (G.) attenuatus* (Jenyns, 1842).

(i) *Punchbowl Creek, Launceston* (A). 23 series. Series 89\*, 8/10/35; 90\*, 10/11/35; 91\*, 24/11/35; 92\*, 15/12/35; 115\*, 18/10/36; 117\*, 22/11/36; 119\*, 31/12/36; 124\*, 31/1/37; 125\*, 126\*, 14/2/37; 129\*, 21/3/37; 145\*, 24/10/38; 146\*, 19/11/38; 151\*, 31/12/38; 153, 8/1/39 (E. Chugg); 156\*, 29/1/39; 157\*, 26/2/39; 158\*, 19/3/39; 159\*, 26/3/39; 166\*, 27/5/39; 167\*, 28/5/39; 171\*, 16/3/40; 172\*, 30/9/40.

(ii) *Other Tasmanian Localities* (B-Z; a-b; d-k). 59 series. Series 1, no locality, no date (Museum coll.); 4\*, Kelso (B), 22/12/33 (R. Slater); 5, Cormiston (C), April 1933 (E. Lumley); 6, Racecourse Creek, Launceston (D), no date (W. Smith); 7, 16, 77\*, 87, 105, Saltwater Creek, Low Head (E), April 1933, 19/3/34, 24/4/35, 6/9/35, 24/7/34 (G. Green); 9, Cook's Creek, Adventure Bay, Bruny Island (F), 24/1/34 (V. V. Hickman); 10, 19, 35, 78, various creeks, northern end of Great Lake (G), 8/2/34, 29/3/34, 3/6/34, 1/5/35 (10 N. J. B. Plomley, 78 R. Wigram); 12, Sulphur Creek (H), 15/2/34 (N. Gill); 17\*, 34, 43\*, 49, 52\*, 53\*, Cox's Creek, Wynyard (I), 29/3/34, 29/5/34, 24/11/34, 11/12/34, 27/12/34, 27/12/34 (17, 34, 43\*, 53 J. Harrison); 18, North Esk at St. Leonards (J), 29/3/34 (A. L. Meston); 24, 65, 66, 96, 97, 130, 154, 169, creeks, drains, lake itself, Great Lake, western shore, near, and south of, Reynold's Neck (K), 2/4/34, 18/2/35, 19/2/35, 27/1/36, 27/1/36, 4/4/37, 23/1/39, 12/2/40 (96, 97, 130, 154 D. Paton, 169 A. Pike); 25, River Brid (L), 4/4/34 (A. L. Meston); 28\*, Franklin (M), 26/4/34 (A. B. Gaul); 30, 60 Pyengana (N), 12/5/34, 6/2/35 (30 E. Hookway, 60 H. Le Fevre); 33, Carroll's Creek, Rocky Cape (O), 21/5/34 (A. L. Meston); 38\*, 39\*, 40\*, River Tamar (P), 17/9/34 (whitebait); 41\*, Upper Scamander (Q), 18/10/34 (A. E. Elms); 54\*, Clayton Rivulet (R), 31/12/34; 71, Tonganah (S), 13/3/35 (K. E. Jackson); 72\*, creeks running into Don River (T), 14/3/35 (A. Smith); 86\*, creek at Spreyton (U), 1/9/35; 88, creek running into River Pieman (V), 8/3/35 (M. White); 93\*, Young Town (W), 28/12/35 (R. Gardam); 95\*, creek about 4 miles south of Sorell, West Coast (X), 2/1/36 (A. L. Meston); 99, Snug River (Y), 16/1/36 (P. B. Edwards); 100\*, Sassafras Creek, at Pardoe Beach (Z), 17/1/36 (A. L. Meston); 108\*, Latrobe (a), 14/9/35 (whitebait); 109\*, Big Eel Creek, near Temma (b), 6/2/36 (S. L. Larnach); 110\*, Mella (d), 17/4/36 (B. Burnley); 116\*, Pedder River (e), 22/1/36 (S. L. Larnach); 118\*, Stony Creek, near Swansea (f), 2/12/36 (G. C. McKinlay); 120\*, River Pieman, at mouth (g), 23/1/37 (A. L. Meston); 121, River Pieman, at Corinna (h), 23/1/37 (A. L. Meston); 122, Middleton's Creek (i), 24/1/37 (A. L. Meston); 140\*, Welcome River (j), 7/1/37 (A. L. Meston); 161\*, 163\*, Mowbray, Launceston (k), 1/4/39, 17/4/39 (F. Frankcombe).

(iii) *Islands of Bass Strait; Victoria*. (These localities not included in map, Text-fig. 1). 5 series. Series 32, Currie, King Island, 19/5/34 (M. C. Challis); 59, 69, Clarke Island, 30/1/35, 9/3/35 (A. MacLaine); 68, Yarra River, Abbotsford, Victoria; Lilypillly Gully, National Park, Victoria; creek near Timboon, Victoria; Marat Creek, Pakenham, Victoria (exchange, National Museum, Melbourne); 164, Rhodes' Creek, western side of Mt. Strzelecki, Flinders Island, 16/1/38 (C. Davis).

(iv) *Tank Series*. Numerous specimens from various localities (most important, Punchbowl Creek, Launceston, and Great Lake) have been kept alive in observation tanks over a period of about five years.

(v) *Overseas Museums Material*. Material in the collection of the National Museum, Melbourne; Australian Museum, Sydney; British Museum (Natural History), London; Muséum National d'Histoire Naturelle, Paris; Museum für Naturkunde, Berlin; and a number of Museums in U.S.A. has also been examined.

#### DISTRIBUTION: ABUNDANCE

(a) *General*. Tasmania, including Bruny Island (Series 9), King Island (Johnston, 1888; Series 32), Clarke Island (Scott, 1936a; Series 59, 69), Flinders Island (Series 164), Victoria. McCulloch (1915) incidentally mentions South Australia: this State is not included in the Check-list (McCulloch, 1929), and I can find no other published record for it. The British Museum (Natural History) has seven specimens, of which there appears to be no published account, labelled

'New South Wales: Stead'. Not known from New Zealand: it has been shown (Scott, 1936a) that the designation by McCulloch (1929, p. 48) of New Zealand as type-locality is an error.

(b) *Tasmania*. Most rivers and streams (Text-fig. 1); common in Great Lake. No authentic data available regarding far South-West, or Lake St. Clair. Not included in upwards of 200 Galaxiids examined from Cradle Valley district.

(c) *Abundance*. In Tasmania *G. (G.) truttaceus* ranks next in abundance to *G. (G.) attenuatus*. Mack (1936) has noted it occupies a similar position in Victoria.

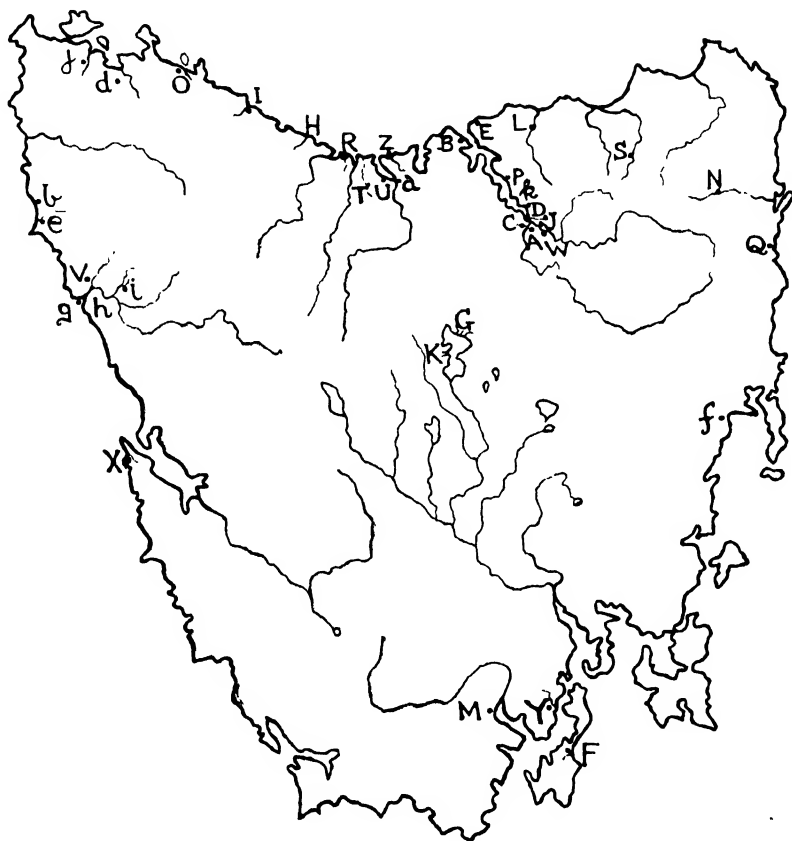


FIG. 1.—Sketch map of Tasmanian localities of material examined. For reference-letters see text.

#### SALINITY TOLERANCE

(a) *Salinity Tolerance*. All information available in the literature would indicate that in Tasmania *G. (G.) truttaceus* is confined to the Central Plateau, and fresh water of inland creeks and upper reaches of rivers. Thus Johnston (1883, p. 130) observes 'Abundant in most of our freshwater streams, but not descending to brackish water like *G. attenuatus*'; and Lord and Scott (1924, p. 23) expressly state it 'does not occur in the lower reaches and brackish estuaries,



where its place is taken by the 'Jollytail' [i.e., *G. (G.) attenuatus*]. Actually, I find, *G. (G.) truttaceus* descends right to the beach-line: indeed, some observations made at Stanley in October, 1935, though unverified by the actual collection of material, strongly suggest it may upon occasion enter the sea on the falling tide.

Records from salt or highly brackish water include: Kelso (Series 4); Salt-water Creek, Low Head (7, 16, 77\*, 87, 105); Sulphur Creek, about 300 yards from the sea (12); Upper Scamander (41\*); Clayton Rivulet, below railway, at upper limit of beach (54\*); brackish creek, Clarke Island, Bass Strait, 200-300 yards from sea (69); Sassafras Creek, Pardoe Beach, close to mouth, at a point to which the high tide backs up (100\*); mouth of River Pieman (120\*): (asterisk indicates presence in sample of *G. (G.) attenuatus*).

In several cases the available material affords information regarding the occurrence of the fish at widely separated points in the same waterway. Thus Series 120, 121, 122, collected within two days, provide examples from mouth of River Pieman (associated with *G. (G.) attenuatus*); the Pieman at Corinna (about 14 miles from sea by water), where water is still tidal, somewhat brackish; and from Middleton's Creek (fresh water), a tributary of the Savage, itself a tributary of the Pieman, into which it empties a mile or so below Corinna: further, Series 88 provides specimens from a creek draining into the Pieman some 7 miles from the coast. Again, in the River Tamar, samples are available from several localities between the mouth and Launceston, some forty miles inland; and, further *G. (G.) truttaceus* is traceable along lengthy stretches of the North Esk and South Esk, by whose confluence the Tamar is formed.

(b) *Salinity Gradient*. With the abandonment of the conception, hitherto held, that *G. (G.) truttaceus* and *G. (G.) attenuatus* are essentially inland and coastal species, respectively, overlapping and mingling in an intermediate region lying between the upper limits of tidal influence and the foot of the Central Plateau, the question naturally arises as to whether, in Tasmania, the former species exhibits any marked salinity gradient at all. Data bearing on this problem is set out in Table I.

TABLE I

*G. (G.) TRUTTACEUS* · *G. (G.) ATTENUATUS* · FREQUENCY RATIO IN WATERS OF VARYING SALINITY

Salinity-category	No. of Localities	No. of Series	Number of Specimens					
			<i>G. (G.) truttaceus</i>	<i>G. (G.) attenuatus</i>	Total	Average No. in Sample	<i>G. (G.) truttaceus</i> %	
Salt or highly brackish	5	5	45	60	105	21	42.9	
Moderately brackish	3	6	28	117	145	24	19.8	
Fresh {	(a) Punchbowl Creek	1	19	202	640	842	44	24.0
	(b) Other Localities	9	9	24	90	114	28	21.1
	(c) Total	10	28	226	780	956	35	25.2

An analysis of samples (16 localities, 20 series, 192 specimens) of *G. (G.) truttaceus* from localities in which *G. (G.) attenuatus* occurs (e.g., Great Lake series excluded), but unassociated, as collected, with that species, yields the following additional data: salt or highly brackish water, 2 localities, 3 series, 39 specimens, average number per sample 13; moderately brackish water, 6, 8, 73, 9; fresh water, 8, 9, 80, 9.

While the information recorded in Table I, not being based on material collected expressly in relation to the present problem (note, e.g., disregard of seasons, possible tendency of some collectors to concentrate on one particular species, &c.), does not provide rigorously random sampling on which to base a proper quantitative analysis (e.g., a satisfactory computation of Forbes' coefficient of association), nevertheless, it does appear generally decidedly unfavourable to an assumption of an inverse correlation in this species between frequency and salinity.

(c) *Experimental Evidence.* That *G. (G.) truttaceus* behaves, under laboratory conditions, as a euryhaline form has been demonstrated by a number of experiments in which fish have been brought from fresh to (artificial) sea-water—average analysis of Dittmar (1884)—and *vice versa*, without suffering any serious disturbance of metabolism, or exhibiting any marked changes of behaviour, other than temporarily enhanced general liveliness and quickened respiratory rhythm on being subjected to an abrupt increase in salinity. These trials have varied in severity from, on the one hand, starting with tap-water, a regular increase in salinity of 3.5 gm per 1000 gm on each of 10 successive days, to, on the other hand, direct transference from tap-water to sea-water of salinity 35 gm per 1000 gm: in no instance has the fish manifested any noteworthy symptom of distress.

#### ASSOCIATION WITH *G. (G.) ATTENUATUS*

(i) *General.* That *G. (G.) truttaceus* forms a consociates with *G. (G.) attenuatus* over the whole ecological range of the latter species is sufficiently established by the facts recorded above. In many localities the two species are found occupying the same pool: in captivity they share a tank in complete community.

(ii) *Whitebait.* It has been shown (Scott, 1936b) that young individuals of *G. (G.) truttaceus* and *G. (G.) attenuatus* form a minor constituent of Tasmanian 'whitebait', in which they are associated with the haplochitonid *Lovettia sealii* (Johnston)—the 'whitebait' of New Zealand largely consists (Clarke, 1899; Phillipps, 1919) of *inanga*, or *G. (G.) attenuatus* fry. Schools of whitebait, often comprising an almost incredible number of individuals, appear in Northern Tasmanian rivers and in the Derwent in Spring.

It is generally accepted that the Galaxiidae are a group of Salmonoids of marine origin, related to the Osmeridae (Regan, 1906, 1913), which, like the Northern circumpolar Salmonidae, are establishing themselves in fresh water; and it is well established (Hutton, 1896; Clarke, 1899; Best, 1903; Whitely, 1935) that in New Zealand *G. (G.) attenuatus* descends to the sea periodically to spawn. The presence of *G. (G.) truttaceus*, as fry, in whitebait, and observations on its occurrence in Punchbowl Creek noted below suggest that this species is not improbably facultatively catadromous, and that, when not confined in landlocked waters, it may retain the presumably primitive spawning habit of the family.

(iii) *Punchbowl Creek.* In Punchbowl Creek, Launceston, *G. (G.) truttaceus* and *G. (G.) attenuatus* commonly occur together, with the latter species present in greater abundance. It is, however, worthy of note that over the period 6/2/34-7/10/35 the whole catch of 12 series, comprising 310 specimens, from this locality consisted exclusively of *G. (G.) attenuatus*. While experience has shown that *G.*

(*G.*) *truttaceus*, except when young, is more wary of the trap employed in these investigations (for description, see Scott, 1938, p. 116)—with adult fish, it is quite customary, in a pool containing, say, twenty *G. (G.) attenuatus* and ten *G. (G.) truttaceus*, to trap fifteen of the former species without securing one specimen of the latter—it seems probable these results are to be interpreted as indicative of the failure in 1934 of the normal vernal immigration of *G. (G.) truttaceus* discussed below. In Punchbowl Creek the great majority of specimens, apart from fry, are only of moderate size (LS 60-75): large individuals are unusual, but I have measured examples up to LS 150.

#### ASSOCIATION WITH OTHER GALAXIIDS

In Tasmania *G. (G.) truttaceus* probably occurs associated with all our local Galaxiidae. Its association with the following species has been established: *G. (G.) attenuatus* (*vide supra*), *G. (G.) auratus* (Great Lake, *vide* Johnston), *G. (G.) parkeri* (Great Lake, Snug River), *G. (G.) scopus* (Clarke Island, Bass Strait, in same series as holotype): it is recorded from the type-locality of *G. (G.) weedoni* (River Mersey), *Saxilaga (S.) anguilliformis* (Cox's Creek, Wynyard). I have no authentic records of it in association with *Paragalaxias shannonensis* (known only from type-locality, Shannon River), *Saxilaga (S.) cleaveri* (based on unique holotype, found in eucalyptus stump, West Ulverstone), *G. (G.) johnstoni* (known only from four specimens, creek, near Nive River), *G. (G.) affinis* (type-locality Lake St. Clair): further investigations will, however, probably establish it as an associate of these four forms.

#### VERNAL JUVENILE MIGRATION

(a) *General*. The occurrence of *G. (G.) truttaceus* in whitebait, and the appearance of fry in Punchbowl Creek have already been noted: the latter migration is discussed below.

(b) *Periodicity*. Series taken in Punchbowl Creek between February, 1934 and October, 1935 contained no specimens. In the early part of the summer of 1935-6, however, with the immigration into the Creek of *G. (G.) attenuatus* fry (this migration has been studied in a previous paper; Scott, 1938), there came also an invasion of juvenile *G. (G.) truttaceus*, which penetrated in large numbers into the second, or *Larnoo*, section (for ecological divisions of Creek see Scott, 1938, p. 116, footnote), and, in diminished numbers, to the upper limit of the third. Analysis of the four series 89-92, 8th October - 15th December, 1935, *Larnoo* section, shows that of 51, 17, 73, 88 specimens of mixed *G. (G.) attenuatus* and *G. (G.) truttaceus* 18, 7, 18, 38, an average of 35%, were the latter species: the great majority were juvenile (only exceptions, 2 specimens of Series 89, of LT 68.5, 87.0). Further observations in this section were rendered impracticable by the sudden and almost complete drying-up of the Creek, resulting in a heavy mortality, in which *G. (G.) truttaceus* suffered proportionally much more severely than *G. (G.) attenuatus*, a score or more individuals often being found lying in a square yard on the bed of a dried-up pool in which the failure of the stream had trapped them.

Samples from the *Larnoo* section on 27th September, 1936 (Series 113) and 4th October (Series 114) consisted exclusively of large examples of *G. (G.) attenuatus*, and an inspection made on 11th October showed that the juvenile immigration for the year still had not then begun, the influx taking place between the last-mentioned date and 18th October. *G. (G.) truttaceus* was present this year in decidedly smaller proportion than in the preceding year, Series 115, 117,

119 (October, November, December, 1936) consisting of 69, 83, 20 specimens, of which 4, 4, 4 were *G. (G.) truttaceus*, an average of 7%. This percentage was virtually maintained during the first quarter of the next year, Series 124-126, 129, taken between 31st January and 21st March, 1937, comprising in all 156 specimens, of which 9 were *G. (G.) truttaceus*.

No observations were made in the spring of 1937. In 1938 the immigration had occurred by 24th October, a sample on that date containing 18 *G. (G.) attenuatus* and 11 *G. (G.) truttaceus*. Series 146, 151, taken in November and December, contained 11 (20%) and 8 (17%) of *G. (G.) truttaceus*, an average for the last three months of 1938 of 23%. Five samples in the first five months of 1939 consisted of 143 fish, of which 13 (9%) were *G. (G.) truttaceus*.

The vernal immigration of 1939 was not recorded. A sample of upwards of 50 fish on 30th September, 1940 (Series 172) included 2 early arrivals of the 1940 class of *G. (G.) attenuatus*: a week later, the main body had arrived, a sample of 47 from the *Queechy* section containing 37 juveniles. This year the *G. (G.) truttaceus* element was small, Series 172 including only a few specimens, Series 173 none.

It is thus established that there commonly occurs in Punchbowl Creek an extensive immigration of juvenile *G. (G.) truttaceus*, in company with *G. (G.) attenuatus* fry, the main body of fish arriving in late September - early October. A possible secondary invasion in February - March is noted below.

(b) *Metrical Characters*. The standard length of 10 samples (trapped) of juvenile *G. (G.) truttaceus* population in Punchbowl Creek in October - December 1935, 1936, 1938 is specified in Table II.

Table II shows the vernal immigrant population is essentially a juvenile one, having  $x_{LS}$  about 47, and modal LS-class 45.5 ( $h = 1$ ).

The data afford no clear evidence regarding growth during the three months under review. It is possible secondary minor waves of invasion may occur, especially since frequency polygons for *G. (G.) attenuatus* in Punchbowl Creek exhibit (Scott, 1938) a primary mode in LS-class 45 ( $h = 10$ ), and a secondary mode in LS-class 35 ( $h = 10$ ), apparently indicative of a second juvenile invasion of that species in February - March. In this connexion, analysis of LS specifications of samples collected in the early months of the year (not included in Table II) yields two noteworthy facts: first, in 1937 (no data for 1936) the smallest specimen of *G. (G.) truttaceus* secured in these investigations (LS 37.8) was obtained on 14th February,  $\bar{x}_{LS}$  of the whole sample taken on that date being 40.2, decidedly less than  $x_{LS}$  for samples (Series 124, 129) in January and March; secondly, in 1939 (no data for 1938) a sample (Series 158) in March (one specimen only) had LS 46.5, compared with  $\bar{x}_{LS}$  50.4, 53.7, 56.0, 48.9 for samples (Series 156, 157, 166, 167) collected in January, February, May (2 samples in May).

With  $h = 1$ , LS distribution of the 130 specimens in Table II is; ( $f_{41.5}$ ) - ( $f_{57.2}$ ) = 6, 7, 10, 13, 19, 15, 10, 10, 11, 8, 8, 2, 2, 4, 2, 1, 2.

(c) *Non-Metrical Characters*. On arrival in Punchbowl Creek, some individuals still exhibit a furrow with double raised flanking walls locating the region of absorption of the yolk-sac, and, slightly dorsad of this depression, a subspherical vascular plexus, clearly visible through the transparent body-wall as a red spot.

Pigmentation is little developed. In 1935, October specimens exhibited Colour-Phase A (see Colour-Phases, below); on 11th November 5 out of 7 had advanced to middle and late subphases of Phase B; on 24th November a sample of 18 included

TABLE II

GALAXIAS (G.) TRUTTACEUS. STANDARD LENGTH SPECIFICATION OF JUVENILE POPULATION IMMIGRANT INTO PUNCHBOWL CREEK, LAUNCESTON, OCTOBER, NOVEMBER, DECEMBER, 1935, 1936, 1938

Year	Series No.	No. of Specimens	Min.	Max.	$\bar{x}$	Mode (1)	Q	Md	Q <sub>3</sub>	$\sigma$
1935	89	8/10/35	16 (2)	45.0	57.5	46.99	46.5 [4]	44.7	46.2	48.6
	90	10/11/35	7	43.8	54.5	48.97	(1)	46.0	49.0	51.0
	91	24/11/35	18	43.0	55.1	48.38	45.5 [3]	45.5	47.7	51.4
	92	15/12/35	38	41.2	57.7	45.29	44.5 [7]	43.1	44.7	46.4
Totals and Means, 1935	4 Series	8/10/35-15/12/35	79	41.2	57.7	46.66	(4)	44.0	45.8	49.0
1936	115	18/10/36	4	45.6	51.6	47.95	47.5 [2]	46.3	47.8	49.6
	117	22/11/36	4	46.1	53.8	49.28	46.5 [2]	46.4	48.8	52.1
	119	31/12/36	4	48.8	51.6	50.23	(1)	49.4	50.3	51.1
Totals and Means, 1936	3 Series	18/10/36-31/12/36	12	45.6	53.8	49.15	(5)	46.9	49.9	51.1
1938	145	24/10/38	11	45.7	52.8	49.27	48.5 [3]	47.8	48.6	51.1
	146	19/11/38	20	42.2	55.8	45.95	45.5 [6]	44.0	45.2	46.8
	151	31/12/38	8	42.4	56.0	49.00	48.5 [2]	46.9	49.0	51.0
Totals and Means, 1938	3 Series	24/10/38-31/12/38	39	42.2	56.0	47.51	45.5 [8]	45.0	47.1	50.0
Totals and Means, 1935, 1936, 1938	10 Series	Oct.-Dec., 1935-6-8	130	41.2	57.7	47.15	45.5 [19]	44.6	46.4	49.4

(1) Mode with  $h = 1$ ; figures in brackets denote number of cases.

(2) Two specimens of LS 61.2, 75.5, clearly belonging to previous year-class, omitted from Table

(3) With  $h = 1$ , no mode.

(4) With  $h = 1$ , plurimodal: 44.5, 45.5, 46.5 classes each with 10 cases.

(5) With  $h = 1$ , plurimodal: 46.5, 47.5, 50.5, 51.5 classes each with 2 cases.

several individuals in Interphase B C. In 1936-7, October arrivals were in Phase A, reaching B by late November, Interphase BC in January and February, and Phase C in March. In 1938, 10 of 11 specimens taken on 24th October were in Interphase AB, one individual being in subphase Bd; of 20 fish on 19th November, 17 were in late, 1 in middle, 1 in early Phase B, while one individual had arrived at Phase C. Samples of the 1938 class collected in January, February, March, 1939 were in Phase B, Interphase B C, Phase C: of 9 specimens in May (Series 166, 167 pooled) 1 was in advanced Interphase B C, the rest in Phase C.

#### VARIATION OF COLOUR-PATTERN WITH GROWTH: COLOUR VARIETIES

(a) **General.** Our knowledge of colour-pattern in the Galaxiidae is scanty. Of possible differences associated with sex, season, locality we know virtually, or literally, nothing: of individual variation as much as, but no more than, the systematist records in the compilation of his specific diagnoses. Colour-varieties in *G. (G.) truttaceus*, long known, are discussed in subsection (d) below. In a previous paper (Scott, 1936a, p. 94) some tentative associations of colour-pattern types (spots, bars, blotches) with other diagnostic features have been made in the characterization of what appear to be species-groups. Variations of colour-pattern with age have been the subject of references, more or less incidental in character, by Clarke (1899), *G. (G.) kokopu*; Regan (1906), *G. (G.) lynx*, *G. (G.) weedoni* (Lake Laura specimens); McCulloch (1915), *G. (G.) attenuatus*; Eigenmann (1924), *G. (G.) maculatus*, *G. (G.) globiceps*; Scott (1936a), *G. (G.) parkeri*; Whitley and Phillips (1939) *G. (G.) argenteus*: in general, these observations have been concerned with a progressive increase in extent, and at times in complexity, of pigment-deposition (Clarke, however, notes markings on body of *G. (G.) kokopu* are relatively larger in young).

Though the genotype of *Galaxias* has now been known to science for nearly a century and a quarter, the fact that it manifests a regular sequence of changes in colour-pattern appears hitherto entirely to have escaped notice. So far as I can ascertain, references in the literature to colour-markings on the body of this species are consistently confined to mention of the annulated dark spots regularly, and the dark post-pectoral bar or bars usually, present in the adult—e.g., “readily recognized by the trout-like black spots on the sides of the body” (Mack, 1936): note, also, McCoy’s (1866) significant synonymic specific name *ocellatus*. The present investigations show that *G. (G.) truttaceus* exhibits a series of successive colour-pattern phases almost as marked as, and presenting at least a superficial resemblance to, that encountered in certain Salmonidae.

My attention was first drawn to this circumstance by the receipt, in March, 1934, of specimens of what, judged from the colour-pattern alone, would naturally be taken for an undescribed species. Subsequent investigation revealed the presence of a strikingly barred, wholly unspotted phase of *G. (G.) truttaceus* in Punchbowl Creek: the complete pattern-sequence has since been thoroughly established by systematic collecting in this locality, supplemented by the keeping of this species under observation in fish-tanks continuously over a period of several years.

(b) **Colour-Phases.** Three phases, two interphases, and about ten subphases may be recognized. While clearly chronologically successive, the subphases manifest some overlapping (particularly in samples from different localities, and, to some extent, in different year-classes) when regarded as a direct function of size, LS min. of one phase in one series being sometimes exceeded by LS max. of preceding phase in another sample: cf. observations by Eigenmann (1924, p. 50) on

variation in duration of retention of unspotted juvenile condition in *G. (G.) maculatus*. Marked differences in bodily proportion (subsection (c)) characterize the primary phases. The following analysis, based primarily on Punchbowl Creek material, is confined to macroscopic features: microscopic aspects of the changes involved are of interest, and worthy of detailed study.

*Phase A: Unornamented Stage.* (The term 'unornamented', not strictly accurate, conveniently connotes complete absence of body-bars and large spots consistently present in succeeding phases). In very young, presumably immediately post-larval specimens (Plate IX, Fig. 2) the body is transparent: ornamentation is confined to the caudal fin, and comprises, first, a highly characteristic vertical dark, almost black basal bar, commonly about  $\frac{1}{2}$ - $\frac{1}{3}$  eye-diameter in width; secondly, a series of 6-10 proconcave dark arcs covering most of the fin (often better developed at a somewhat later stage). In whitebait samples the caudal bar may be in two (united) halves, each with a convex posterior margin.

The pre-pigmentation stage in Galaxiids has been recorded for *G. (G.) maculatus* by Eigenmann (1924): for *G. (G.) attenuatus* by McCulloch (1915), Scott (1938); see also speculation by Regan (1906) as to the possibility of *G. (G.) gracillimus* being a larval form of this species. The presence in very young *G. (G.) truttaceus* of a patterned caudal fin lends support to a suggestion (Scott, 1938, p. 121) that this feature may well be a primitive family character, enjoying brief ontogenetic manifestation. It should be noted that the extensive proximal caudal bar of *G. (G.) truttaceus* is entirely absent in *G. (G.) attenuatus*.

Individuals in Phase A occur among whitebait, and in recently arrived vernal influxes in Punchbowl Creek. They are commonly of  $LS\ 43 \pm 5$ , but unornamented individuals of  $LS > 52$  occasionally occur.

*Interphase AB: Preliminary Pigmentation Stage.* The interesting early stages of somatic pigmentation are predominantly microscopic; macroscopically they result in a slight decrease in transparency (especially above mediolateral line), quite evident in preserved material, barely noticeable in life; and in the first pigmentary outlining of the myomeres. Basal caudal bar conspicuous; caudal arc-pattern usually most apparent in this stage (Fig. 3). Punchbowl Creek examples have been taken in late October.

*Phase B: Barred Stage.* In the course of this stage the young fish gradually develops a series of forwardly directed chevrons or subvertical bars (angulation frequently markedly more acute posteriorly) that lend it an appearance strikingly at variance with that of the adult. Bars, which are most prominent in Cox's Creek specimens (Fig. 16), commonly number 12-15: on the average, in Punchbowl Creek and Cox's Creek material bars are rather narrower than, in Great Lake specimens about one-half as wide as, their interspaces.

The normal schedule of bar-development appears to be as follows. *Subphase Ba* (Fig. 4): upper halves only of chevrons extending progressively from head to level of pelvic origin. *Subphase Bb* (Fig. 5): the same, continued to level of vent. *Subphase Bc* (Fig. 6): head-pelvic interspace with chevrons complete; pelvic-anal interspace with half-bars above mediolateral line; postanal region bare. *Subphase Bd* (Fig. 7): chevrons complete to level of base of anal fin; postanal region bare. *Subphase Be* (Fig. 8): upper halves of bars now developed on caudal peduncle. *Subphase Bf* (Fig. 9): complete series of chevrons or bars from behind head to base of caudal.

Occasional departures from the normal programme include: (i) appearance of two or three full chevrons prior to complete development of superolateral series of half-bars (Fig. 17); (ii) omission of Subphase Be, with Bd passing directly

into Bf. In general, however, the sequence follows a well-marked course involving, first, the preanal region, with progressive development caudad of half-bars, then of complete bars; secondly, the postanal region, with similar succession.

Basal caudal bar now less conspicuous; caudal fin pattern normally almost, or wholly, lost; blackish oblique suborbital streak and dark upper labial marking, characteristic specific characters of adult *G. (G.) truttaceus*, begin to appear.

Fish exhibiting Colour-Phase B are commonly of  $LS\ 45 \pm 3$ , with recorded extremes of 37.8 and 56.7 (Punchbowl Creek);  $50 \pm 4$  (Cox's Creek);  $45 \pm 3$  (Great Lake). Punchbowl Creek individuals normally exhibit this colour-stage in November (exceptionally, as early as late October, as late as January); Cox's Creek specimens were taken in March, November, December; examples are included in Great Lake series collected in January, March.

*Interphase BC: Barred-Spotted Stage.* Shortly after establishment of Subphase Bf, there sets in a progress of disintegration of chevrons and bars into subvertical linear series of spots. This process proceeds in the reverse direction from bar-formation, becoming initiated on the caudal peduncle, and extending gradually (at times somewhat irregularly) cephalad: again in contrast to the sequence of events encountered in Phase B, the superolateral and inferolateral regions of the body are here involved contemporaneously (occasionally an odd bar or two becomes discrete first in its superior moiety). Three subphases may conveniently be recognized. *Subphase BCa* (Fig. 10): caudal peduncle with rows of spots; rest of body with bars. *Subphase BCb* (Fig. 11): region caudad of about mid-point of pelvic-anal interspace with rows of spots; region anterior to this barred: commonly, the anterior two (or three) bars that will constitute the adult shoulder-markings now broaden and darken, and, in individuals destined to develop them, the yellow bands between these emphasized anterior bars become more or less pronounced. *Subphase BCc* (Fig. 12): as in BCb, but with tendency towards the breaking-up of one or two bars at, or in advance of, level of pelvic, bars posterior to this still remaining intact.

Basal caudal bar much diminished in width and intensity; suborbital streak and upper labial marking fully developed; dusky tips to pelvic, dorsal, and anal, if present in adult, begin to appear.

Punchbowl Creek specimens in Interphase BC, though occasionally present in late November, do not become common till December or January: they are the characteristic form in February samples, and may exceptionally be taken as late as May. Modal  $LS\ 49 \pm 3$  (Punchbowl Creek); Cox's Creek and Great Lake examples of about the same size were taken in March.

*Phase C: Spotted Stage.* While the stage immediately following Subphase BCc finds the colour-pattern composed entirely of spots (save for permanent post-pectoral bars), adult marking is not yet achieved, Phase C comprising three subphases. *Subphase Ca* (Fig. 13): subvertical bars of subphase Bf wholly resolved into rows of smallish spots. *Subphase Cb* (Fig. 14): regular spot-pattern suffers disruption; linear arrangement of spots, though invariably lost first on caudal peduncle, and persisting longest in head-pelvic interspace, manifests only a general tendency towards progressive disintegration cephalad, frequently occurring discontinuously; concurrently with assumption of random spotting (which involves reduction in frequency, increase in dimensions, of spots) there generally occurs a movement towards the differentiation of the larger spots often present below part, or whole, of dorsal profile, these specialized spots being usually the first to become annulated. *Subphase Cc* (Fig. 15): the normal adult colour-pattern, with scattered large spots, of which many, usually most, are ocellated.



In Punchbowl Creek, fish arriving as fry in October attain the final colour-pattern by about March, or April (exceptionally not till May or even later).

The probable partial correlation of extent of shoulder-markings with age is discussed in subsection (d) below.

(c) **Metrical Characters of Colour-Phases.** Table III exhibits variation, in the three primary colour-phases, of twelve diagnostic body-ratios and fin-ratios: entries for Phase A are based on Series 115 (4 specimens); B, Series 17, 49, 53, 54 (8); C, Series 33, part (10).

TABLE III

GALAXIAS (G) TRUTTACEUS VARIATION OF 12 BODY-RATIOS AND FIN RATIOS IN THE THREE PRIMARY COLOUR-PHASES

Dimension or Ratio	Colour-Phase	Min.	Max.	$\bar{x}$	$\sigma$
Standard length, L.S. in mm	A	15.6	51.6	47.95	2.573
	B	51.0	59.0	54.34	2.777
	C	98.1	109.1	102.66	4.623
Head in LS	A	5.7	6.3	5.90	0.283
	B	4.5	5.0	4.76	0.173
	C	4.8	5.1	4.99	0.477
Depth in LS	A	7.5	8.6	8.20	0.496
	B	5.6	7.6	6.63	0.549
	C	4.3	5.4	4.91	0.324
Eye in head	A	3.5	3.6	3.55	0.054
	B	3.8	4.4	4.04	0.230
	C	4.4	5.4	4.92	0.405
Eye in snout	A	0.9	1.0	0.95	0.064
	B	1.2	1.0	1.13	0.075
	C	1.2	1.5	1.32	0.105
Eye in interorbital width	A	1.2	1.5	1.35	0.141
	B	1.5	1.7	1.58	0.925
	C	2.0	2.5	2.18	0.200
Length of caudal peduncle in LS	A	6.9	7.0	6.98	0.577
	B	6.7	8.9	7.71	0.694
	C	8.3	9.9	8.94	0.498
Depth of caudal peduncle in its length	A	1.8	2.0	1.90	0.082
	B	1.3	1.7	1.45	0.165
	C	1.3	1.4	1.35	0.075
Length to pelvic fin in LS	A	2.11	2.14	2.12	0.0153
	B	1.95	2.02	1.99	0.0229
	C	1.82	1.98	1.89	0.0054
Length to dorsal fin in LS	A	1.43	1.49	1.46	0.0271
	B	1.40	1.47	1.42	0.0332
	C	1.35	1.38	1.38	0.0167
Length of pectoral fin in pectoral-pelvic interval	A	2.4	2.7	2.48	0.141
	B	1.8	2.1	2.01	0.105
	C	1.8	2.1	1.92	0.120
Length of pelvic fin in pelvic-anal interval	A	2.2	2.3	2.25	0.082
	B	1.6	2.1	1.91	0.015
	C	1.6	1.9	1.78	0.100
Combined base of dorsal and anal fins in LS	A	3.8	4.2	3.98	0.208
	B	3.8	4.2	3.97	0.141
	C	4.2	4.9	4.54	0.691

Table III shows: (i) points of origin of dorsal and pelvic constitute important morphological landmark, subject, in a given length-class, to little individual variation: (ii) with increase in LS, relative length of head appears, on present data, first to decrease, then slightly to increase; results are perhaps exceptional, normal course probably being a progressive decrease: (iii) with increasing LS eye becomes smaller, relative to head, snout, interorbital width; body grows deeper; caudal peduncle becomes deeper, also shorter relative to LS; lengths to dorsal and pelvic origins increase; combined bases of vertical fins become relatively smaller; lengths of pectoral and pelvic, relative to fin-interspaces, increase: (iv) except that of combined bases of vertical fins, in which there is no significant difference on average between Colour-Phases A and B, all changes noted in (iii) are clearly progressive, and ratios yield distinctive figures for each colour-phase.

(d) **Colour Varieties.** Johnston (1883, p. 131) states: 'There are two or three varieties: Var. *a*.—In the North Esk, without the three characteristic cross-bars upon the shoulder. Var. *b*, Mountain Trout.—Without spots or bars; head more depressed. Colour, grey, with beautiful iridescent specks of green and gold. Mount Wellington. Var. *c*.—A red-finned variety, found in streams at Gould's Country'. Regan (1906, p. 379) admits: '*A. Forma typica*, with 2 or 3 dark vertical bars above the pectoral and with the dorsal, anal, and ventral fins blackish at the tip [all his specimens from Tasmania]: B. Variety without bars above the pectoral, with the fins uniformly pale' two specimens from Moorabool River, Victoria [Johnston's reference to Tasmanian examples without bars above pectoral noted].

Examination of the present material yields the following results. (i) *General Body-Colour*: greyish, greyish green, pale green, dark green, yellowish green, yellow, yellowish pink, greyish purple, and other tints; some West Coast specimens (*e.g.*, Series 88, 120) very dark purplish, almost black. (ii) *Pectoral*: usually colourless, but may be greyish or greenish, becoming somewhat lighter or somewhat darker distally; not tipped with black. (iii) *Dorsal and Anal*: virtually colourless; almost colourless proximally, faintly dusky distally (common); pale brownish proximally, becoming nearly colourless or darkening almost to black distally; yellowish, with or without black margins (common); successively from base, about one-fourth olivaceous or pale yellowish, five-eighths bright reddish orange or brownish red, one-tenth black, one-fortieth pale ashen (a common succession). (iv) *Shoulder-Bar*: number and extent of bars may vary on two sides of same individual; bars at times absent, but if so, shoulder-region usually bears one or more dark blotches larger than general body-spots; bar usually margined, anteriorly, posteriorly, or both, with area lighter or brighter than general body-colour, this area frequently being, in small specimens sulphur-yellow—there is some evidence to suggest number and distinctness of bars vary with age, Punchbowl Creek specimens of LS 50-60 usually having two prominent bars with conspicuous sulphur-yellow interspace (whole pattern quite apparent in living fish several yards away in water), larger individuals often showing only a single bar; in many series bars are more numerous, relatively larger, and better defined in small than in large fish; in Great Lake material of fair size there is commonly one bar (often relatively smaller in larger specimens), or none, and, in the majority of cases, a moderate or smallish blotch above superior angle of operculum. (v) *Dark Suborbital Streak*: constantly present. (vi) *Upper Lip*: regularly dark. (vii) *Ocellated Spots*: the development of the ocellus, which does not always involve all body-spots, appears to be largely a function of age. (viii) *Spots on Head*: two or three dark spots on operculum, one or two on preoperculum,

sometimes present: body-spots extending on to dorsal surface of head only exceptionally. (ix) *Gold-speckling*: quantity present varies considerably; characteristically much more pronounced in material from high altitudes.

While further investigation on colour varieties is needed, these facts suggest the following observations. (i) There exists no sharp line of demarcation between Regan's A (= Johnston's Var. *a* from North Esk) and Regan's B—thus, we find examples with shoulder-bars and pale fins (Series 86), and with black-tipped fins, and no well-defined shoulder-bar (Series 118)—nevertheless, it remains true that specimens with fins uniformly pale, or with slight distal duskiness in pelvic, dorsal, anal usually, though not invariably, have the post-pectoral bars reduced to blotches, considerably, or occasionally but slightly, larger than ordinary body-spots: such a form occurs not only in the North Esk (where it is associated with other varieties), but in many widely separated localities, including the Central Plateau, where it is common. (ii) Johnston's Var. *c*: specimens with red, black-tipped fins (body usually yellowish or pinkish) are apparently common (Series 30, 60; Pyengana) near Johnston's locality, but are by no means confined to this district (cf. Series 99, 110). (iii) Of Johnston's Var. *b* (the term 'Mountain Trout', applied by Johnston to this form, is now used indiscriminately for all forms of *G. (G.) truttaceus*, wherever found; often, indeed, also for other species of *Galaxias*) no specimens appear to exist in Museums, nor have I been able otherwise to secure any: while, in the absence of material, surmise only is possible, I am much inclined to believe this reference to an unspotted form relates to another species altogether, possibly *G. (G.) affinis*, which seems to agree reasonably well with Johnston's brief description.

#### SPAWNING

(a) *General*. There is no published information on the spawning habits of *G. (G.) truttaceus*. As already suggested, it seems not unlikely that, where circumstances permit, this species migrates to brackish water, possibly even to the sea, to spawn. It is noteworthy that fish with ripe ova are not infrequently secured (Series 33, 77, 110) in localities at, or near, the coast.

(b) *Number and Size of Ova*. Before extrusion, the ova are discharged, as in the Salmonidae, into the abdominal cavity. In a specimen of LS 113 (Series 33) there were counted 5643 ova, of modal diameter (in formalin) of 1.0-1.3 mm.

(c) *Spawning Season*. Specimens with the abdomen markedly distended with masses of ripe ova are taken in April and May. Fish have been stripped, in several seasons, in both these months; but attempts to hatch ova have hitherto proved unsuccessful.

Acknowledgments are made to the Board of Studies, the University of Tasmania, for a research-grant, and to Dr. V. V. Hickman, Ralston Lecturer in Biology, University of Tasmania, for appreciated encouragement and assistance.

## REFERENCES

- BEST, E., 1903.—Food Products of Tuboeland. *Trans. Proc. N.Z. Inst.* XXV. pp. 45-111.
- CLARKE, F. E., 1899.—Notes on New Zealand Galaxiidae, more especially those of the Western Slopes, with Descriptions of New Species, &c. *Trans. Proc. N.Z. Inst.* XXXI. pp. 78-91. Pl. IV-V.
- DITTMAR, W., 1884.—Report on Researches into the Composition of Ocean-Water, collected by H.M.S. Challenger, during the years 1873-1876. *Challenger Scientific Reports*. London.
- EIGENMANN, C. H., 1924.—The Fresh-water Fishes of Chile. *Mem. Nat. Acad. Sc. Philadelphia*, XXII. 22. pp. 1-63. Figs. 1-7 Pl. I-XVI.
- HUTTON, F. W., 1896. Notes on Some New Zealand Fishes, with Description of a New Species. *Trans. Proc. N.Z. Inst.* XXVIII. 1895 (1896). pp. 314-318.
- JOHNSTON, R. M., 1883.—General and Critical Observations on the Fishes of Tasmania. *Pap. Roy. Soc. Tasm.* 1882 (1883). pp. 53-144.
- , 1888. Notes with respect to the Fresh-water Fishes of King's Island. *Pap. Roy. Soc. Tasm.* 1887 (1888). pp. 74-76.
- LORD, C. E. and SCOTT, H. H., 1924.—A Synopsis of the Vertebrate Animals of Tasmania. Hobart.
- MCCOY, F., 1866. *Intercolonial Exhibition Essay No. 7*.
- MCCULLOCH, A. R., 1915.—The Migration of the Jolly-tail or Eel-gudgeon, *Galaxias attenuatus*, from the Sea to Fresh-water. *Aust. Zool.* 1. 2. pp. 47-49. One text-fig.
- , 1929. A Check-list of the Fishes Recorded from Australia. *Mem. Aust. Mus. Sydney*. V. 1.
- MAC'K, G., 1936.—Victorian Species of the Genus *Galaxias*, with Descriptions of Two New Species. *Mem. Nat. Mus. Melbourne* 9. 1936. pp. 98-101. Two text-figs.
- PHILLIPPS, W. J., 1919.—Life History of the Fish, *Galaxias attenuatus*. *Aust. Zool.* 1. 7. pp. 211-213.
- REGAN, C. T., 1906.—A Revision of the Fishes of the Family Galaxiidae. *Proc. Zool. Soc. London*. 1905. II. (1906). pp. 363-384. Pl. X-XIII.
- , 1913.—The Antarctic Fishes of the Scottish National Antarctic Expedition. *Proc. Roy. Soc. Edin.* XLIX. II. pp. 229-292. Text-figs. 1-6. Pl. I-XI.
- SCOTT, E. O. G., 1936a.—Observations on Fishes of the Family Galaxiidae. Part I. *Pap. Roy. Soc. Tasm.* 1935 (1936). pp. 85-112. Text-figs. 1-4.
- , 1936b.—Observations on some Tasmanian Fishes. Part III. *Pap. Roy. Soc. Tasm.* 1935 (1936). pp. 113-129. Text-figs. 1-3.
- , 1938.—Observations on Fishes of the Family Galaxiidae. Part II. *Pap. Roy. Soc. Tasm.* 1937 (1938). pp. 111-143. Pl. XVIII-XXVII.
- WHITLEY, G. P., 1935.—Whitebait. *Vict. Nat.* LII. 3. 619. pp. 41-51. Text-figs. 1-2.
- WHITLEY, G. P., and PHILLIPPS, W. J., 1940.—Descriptive Notes on Some New Zealand Fishes. *Trans. Proc. Roy. Soc. N.Z.* 69. 2. pp. 228-236. Pl. 21-22.

## PLATE IX

### *Galaxias (G.) truttaceus* Cuvier: COLOUR-PATTERN PHASES

Except in the case of Fig. 14, which represents a specimen from Cox's Creek, Wynyard, the normal sequence of colour-pattern phases (Figs. 2-15) is illustrated by fish from Punchbowl Creek, Launceston. For dates of collection of various Series see text.

For the sake of clearness, the pectoral fin is omitted: details of the remaining fins, other than colour-pattern (where present), are not shown

#### *Colour-Phase A: Unornamented Stage*

FIG. 2. Series 115

#### *Interphase AB: Preliminary Pigmentation Stage*

FIG. 3.—Series 145.

#### *Colour-Phase B: Barred Stage*

FIG. 4.—Subphase Ba. Series 145.

FIG. 5.—Subphase Bb. Series 90.

FIG. 6.—Subphase Bc. Series 91.

FIG. 7.—Subphase Bd. Series 90.

FIG. 8.—Subphase Be. Series 91.

FIG. 9.—Subphase Bf. Series 146

#### *Interphase BC: Barred-Spotted Stage.*

FIG. 10.—Subphase BCa. Series 92.

FIG. 11.—Subphase BCb. Series 92

FIG. 12.—Subphase BCc. Series 45

#### *Colour-Phase C: Spotted Stage*

FIG. 13.—Series 156.

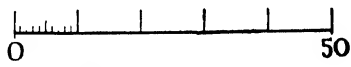
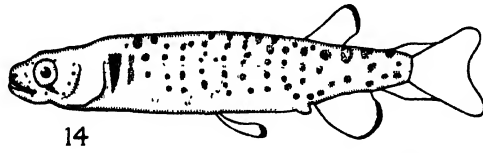
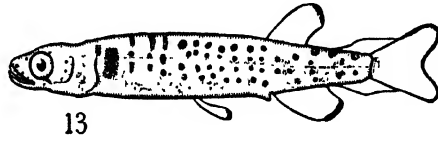
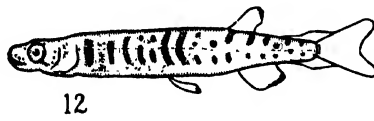
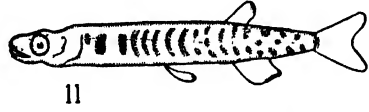
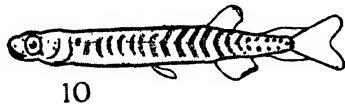
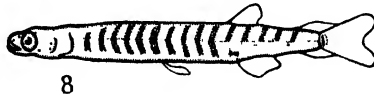
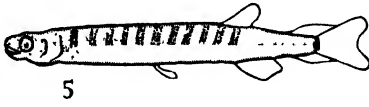
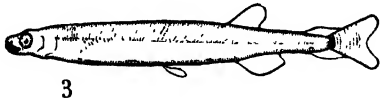
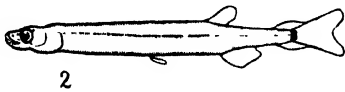
FIG. 14.—Series 34.

FIG. 15.—Series 166.

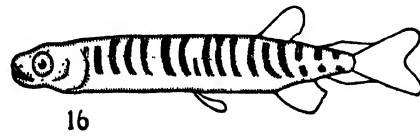
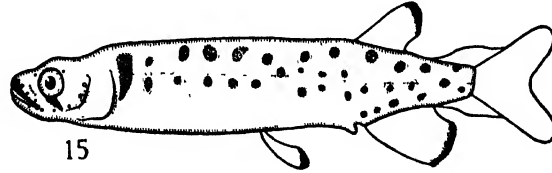
#### *Variations*

FIG. 16.—Specimen from Cox's Creek, Wynyard, showing greater distinctness of barring than that characteristic of Punchbowl Creek specimens. Series 17.

FIG. 17.—Occasional departure from normal sequence, involving formation of some entire bars prior to complete development of superolateral series of half-bars. Series 91.



SCALE : MM.





## Additions and Corrections to *Orchidaceae* of Tasmania

By

W. H. NICHOLLS AND A. M. OLSEN

(Read 11th November, 1940)

### *Prasophyllum Rogersii* Rupp

Plant slender, 20-30 cm. high. Leaf-lamina sometimes exceeding the inflorescence. Flowers in a loose spike, not very numerous, green, the labellum white. Fragrant.

Pedicels very short. Dorsal sepal nearly straight, broad-ovate, acute, 5.5 mm. long, with three prominent nerves and a finer one on each side. Lateral sepals free, more or less spreading, lanceolate, somewhat longer than the dorsal one, hardly acute, 3-nerved. Petals erect, not widely spread, obtuse, fairly broad. Labellum straight for two-thirds of its length from the base, the anterior third merely curved, not sharply reflexed, broadly-ovate, contracted towards the apex; membranous part white, sometimes flushed with pink; margins entire; greatest width about 2.75 mm.; callous part prominent, especially beyond the curve, broader towards the base. Column short, lateral appendages broad. Anther broad, red-brown.

(*Pr. patens*, R.Br. its nearest affinity.)

Distribution: This rare orchid was first recorded and described in 1928 from material collected on Barrington Tops in New South Wales (alt. 5000 ft.). Tasmanian habitat: Knocklofty, near Hobart (alt. 1200 ft.). Collector: A. M. Olsen 1936-1939.

Flowering: December.

### *Prasophyllum patens* R.Br., var. *robusta* Nicholls

Plant more robust than the typical form, about 40 cm. high. Flowers 2 cm. in diameter; spike loose; segments of the perianth widely-spread. Ovary 1-2 cm. long (unusually large for so small a flower). Petals narrow-linear.

Habitat: Smithton. Collector: Archdeacon Atkinson.

Flowering: October.

### *Prasophyllum alpinum* R.Br. (Syn. *Pr. Tadgellianum* Rogers)

Habitat: Mt. Wellington. Collector: Dr. C. S. Sutton. Included under *Pr. fuscum*, R.Br. in 'The Tasmanian Flora', Rodway (1903). See Nicholls, Proc. Roy. Soc. Vict., XLVI (1933), pp. 31-33.



**Prasophyllum Brainei** Rogers

A slender wholly green plant 12-35 cm. high. Flowers often very numerous, green. Labellum white, sessile, forming a complete sigmoid flexure; margins crenulate, very shortly ciliate; callous part green, margins ciliate.

Distribution: Victoria, Tasmania. Tasmanian habitat: East Bank of Don River (North Tas.). Collector: Archdeacon Atkinson.

Flowering: September to January. Very plentiful in habitats.

**Calochilus imberbis** Rogers. 'Beardless Calochilus'

Habitat of plant similar to *Cal. Robertsonii* Benth. Plant 20-37 cm. high. Leaf rigid, fleshy, channelled, linear-lanceolate. Flowers racemose, 3-6 (in Tasmanian specimens), green with purplish markings—chiefly striae. Dorsal sepal cucullate, lateral sepals free, ovate, acute. Petals triangular-falcate, conspicuously marked with purplish veins. Labellum petaloid, sessile, simple, ovate, acute; margins entire, with 7 conspicuous purplish nerves; lamina without calli, hairs or other processes. Column short, the wings connected in front by a high shield-like plate, a purple gland at the base of each.

This plant is well separated from others in the genus by its simple labellum.

Distribution: Victoria, Tasmania. Tasmanian habitat: Woodbridge. Collector: Miss A. M. Wall.

Flowering: October.

**Thelymitra grandiflora** Fitzgerald

The most beautiful of all the Thelymitras. Tasmanian specimens received had large flowers with the column hairtufts golden-yellow.

Habitat: Low Head. Collector: Mrs. F. Perrin.

Flowering: October, November.

**Thelymitra rubra** Fitz.

In place of *Th. carnea* R.Br. in 'The Tasmanian Flora' (p. 189). *Th. carnea* (Syn. *Th. Elizabethae* F. Muell.) is a smaller plant found only in Victoria and New South Wales.

**Corysanthes dilatata** Rupp et Nicholls

In place of *C. pruinosa* Cunn. Cunningham's species is restricted to New South Wales.

**Pterostylis grandiflora** R.Br.

A slender plant 15-35 cm. high. No basal leaves at time of flowering. Stem-leaves lanceolate, acuminate. Flower solitary, white with fine green striae and rich red-brown markings; galea erect then gracefully curved forward, then decurved; apices acute, dorsal point 1 cm. long. Petals widely expanded, red-brown, inner surface often crimson-brown. Lower lip with a flattened sinus, lip projecting, filiform points erect, exceeding the galea by about 4 cm. Labellum irritable, lamina oblong-linear with a long filiform-clavate apex.

This species is often referred to as 'Queen of Greenhoods'.

Flowering (in Tas.): February-August. (May to September on Mainland.)

Distribution: S. and E. Vic., N.S.W.; Q'land; Tas.

Habitat in Tasmania: S.E. side of Flagstaff forming Northern end of Scamander Tier. Collector: A. C. Smith.

***Pterostylis vereena* Rogers**

A wholly green plant similar to *Pt. furcata* Ldl. Basal leaves large, sessile, stem-bracts 2. Very large and leaf-like.

Habitat in Tasmania: Mt. Bischoff. Collector: Archdeacon Atkinson.

Flowering: September-October.

Distribution: South Australia, Tasmania.

A very rare species.

***Pterostylis foliata* Hk.f. (Syn. *Pt. gracilis* Nich.)**

A slender species 12-30 cm. high. Stem-leaves oblong lanceolate, stem-bracts large. Flower solitary, small, green with apex of galea brown. Labellum oblong-elliptical, tip often decurved.

Resembling *Pt. pedunculata* R.Br. in general appearance but easily separated by having larger leaves and stem-bracts, &c. Perhaps more closely related to *Pt. alpina* Rogers but in this case distinguished by the smaller more deeply coloured flower, &c.

Distribution: New Zealand, Victoria, Tasmania.

Tasmanian habitats: Devonport to Smithton (Collector: Archdeacon Atkinson); Mt. Nelson, Mt. Wellington, Launceston (Rev. H. M. Rupp).

Flowering: August-November.

***Pterostylis decurva* Rogers**

In place of *Pt. obtusa* R.Br. in 'The Tasmanian Flora' (p. 198) *Pt. obtusa* is found in Vic., S.A., N.S.W., and Queensland; whilst *Pt. decurva* occurs in Tas., Vic., and N.S.W. Common in mountain districts.

Flowering: October to February, according to altitude.

The detailed description (under *Pt. obtusa*) by Rodway is a good one.

***Pterostylis Toveyana* Ewart et Sharman**

Plant 8-20 cm. high. No basal rosette of leaves at time of flowering. Stem-leaves oblong-ovate or ovate. Flower solitary, green with copper-brown markings. Labellum slightly notched at the apex.

Distribution: Victoria, Tasmania.

Flowering: July-August. Tasmanian habitats: Sandford, Eaglehawk Neck, Flinders Island. Collector: Archdeacon Atkinson.

***Caladenia cordiformis* Rogers**

In place of *Caladenia clavigera* Cunn. in 'The Tasmanian Flora', (p. 204). This detailed description of *C. cordiformis* is typical of the species.

Distribution: Widely distributed in Tas., N.S.W., and Vic.

Tasmanian habitats: Bellerive, Georges Bay, &c.

Flowering: November-December.

***Chiloglottis Pescottiana* Rogers**

(Rogers, Proc. Roy. Soc. Vict., XXX (1933), pp. 139-141.)

A slender plant 8-18 cm. high. Leaves on long petioles, oblong-lanceolate. Flower solitary, greenish-bronze or wholly purplish, with dark-purple calli; lateral sepals linear-lanceolate, recurved, connate at extreme base; dorsal sepal spatulate-acuminate; lateral petals spreading, lanceolate; labellum oblong; calli distributed as follows:—(1) one large crescentic sessile callus in middle line in advance of

all the others; (2) a large bilobed stalked callus about midway between this and base of lamina; (3) numerous stalked calli, small and medium sized, between (1) and (2); (4) a somewhat irregular row of small stalked calli on either side of the middle line from the bend in the lamina to its base. Column winged above; Anther blunt.

Flowering: September-November.

Original habitat on the Mainland: Cravensville (in N.E. Vic.). Original Collector: Mr. A. B. Braine (1907).

Tasmanian habitat: Mt. Barrow. Collector: Mrs. Pearl Messmer of Sydney (N.S.W.), (1940). 'Large colonies interposed between plants of *Chiloglottis Gunnii* Ldl. and *Chil. Muelleri* Fitz.'

# The Royal Society of Tasmania

## 1940

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**Patron:**

His Majesty the King.

**President:**

His Excellency Sir Ernest Clark, K.C.B., K.C.M.G., C.B.E

**Vice-Presidents:**

W. H. Clemes, B.A., B.Sc., retires 1941.

E. E. Unwin, M.Sc., retires 1942.

**Council:**

W. L. Crowther, D.S.O., M.B., retires 1943.

A. L. Meston, M.A., retires 1943.

V. V. Hickman, B.A., D.Sc., retires 1942.

A. N. Lewis, M.C., LL.D., M.H.A., retires 1942.

H. Allport, LL.B., retires 1941.

N. P. Booth, retires 1941.

**Standing Committee:**

W. L. Crowther, A. N. Lewis, V. V. Hickman, J. Pearson.

**Hon. Treasurer:**

S. Angel.

**Hon. Editor:**

Joseph Pearson, D.Sc., F.R.S.E., F.L.S.

**Hon. Auditor:**

Walter E. Taylor, F.F.I.A., F.I.A.S.

**Secretary and Librarian:**

Joseph Pearson, D.Sc., F.R.S.E., F.L.S.

## Annual Report

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The Annual Meeting was held in the Society's Room, Tasmanian Museum and Art Gallery, Hobart, on the 11th March, 1940.

The following Office-bearers were elected:—

Under the Society's Rules Dr. W. L. Crowther retired from the office of Vice-President, and Mr. E. E. Unwin was appointed in his place (retiring 1942).

Treasurer: Mr. S. Angel.

Under the Rules Mr. W. H. Hudspeth and Dr. J. W. Evans retired from the Council, and the following members of Council were elected in their place:—

Dr. W. L. Crowther (retiring 1943).

Mr. A. L. Meston (retiring 1943).

Mr. N. P. Booth was elected to the Council to sit for the unexpired portion of Mr. Unwin's period, namely, one year.

The Council made the following appointments at its first meeting:—

Secretary and Librarian: Dr. Joseph Pearson.

Assistant Librarian: Mrs. Clive Lord.

Standing Committee: Dr. W. L. Crowther, Dr. A. N. Lewis, Dr. V. V. Hickman, and the Secretary.

The Council elected the following two Trustees to serve on the Board of Trustees of the Tasmanian Museum and Art Gallery and the Botanical Gardens in accordance with the amended Tasmanian Museum and Botanical Gardens Act:—Mr. W. H. Clemes and Dr. A. N. Lewis.

Ten meetings were held during the year (see proceedings for abstract of papers). In addition scientific papers were submitted for publication and have been printed in the present volume.

### *Library*

It was agreed, on the recommendation of the Council, to make the following change in the hours of opening the Society's Library:—

That members make use of the Library for reading purposes only when the Assistant-Librarian is present at the following times:—Mondays, 10 a.m.-1 p.m.; Wednesdays and Fridays, 10 a.m.-1 p.m., 2-5 p.m.; on the evenings when a General Meeting is held, 7.30-8 p.m.

During the year 330 volumes were added to the Library in addition to a number of reports and pamphlets from British and foreign countries. The number of Institutions on the Exchange List for the year was 278, being made up of 181 British, 53 American, and 94 from other parts of the world. The Library now consists of 19,889 volumes.

The sum of £34 17s. 3d. was spent on books during the year, and the account was allocated as follows:—

	£	s.	d.
General Fund	10	2	5
R. M. Johnston Fund	8	15	0
Morton Allport Memorial Fund	11	7	5
Beattie Memorial Fund	4	12	5

In addition the Tasmanian Museum spent £6 16s. 1d. on books, which have been placed in the Society's Library for safe-keeping and are available to members.

### *Membership*

The Society consists of the following members:—

	1939.	1940.
Honorary Members	2	2
Corresponding Members	3	3
Life Members	7	7
Ordinary Members	240	227
Associate Members	3	6
	<hr/> 255	<hr/> 245

During the year 21 names were removed from the Membership owing to deaths, resignations, &c., and 8 new names were added.

The Council regrets having to record the death of Sir Herbert Nicholls during the year.

### *Resignation of Auditor*

The Council has accepted with much regret the resignation of Mr. Walter Taylor, both as a member of the Society and as Auditor. Mr. Taylor has rendered valuable work as Auditor since 1926, and his resignation has been caused by his removal to another State.

### *Royal Society Medal*

Two medals of the Royal Society of Tasmania were presented during the year, both at the July meeting, one to Dr. W. L. Crowther for his contributions to Tasmanian ethnology, and one to Dr. V. V. Hickman for his researches on Tasmanian zoology, particularly his work on Tasmanian spiders and the early development of anaspides.

### *Printing of Papers and Proceedings*

Once again the Government has very generously printed the Papers and Proceedings. The Council wishes to record its appreciation of this generous assistance.

## Abstract of Proceedings

8TH FEBRUARY, 1940

A meeting was held in the Society's Room on this date. The President, His Excellency the Governor, Sir Ernest Clark, K.C.B., K.C.M.G., C.B.E., presided.

Professor A. E. V. Richardson, C.M.G., M.A., D.Sc., Deputy Chief Executive Officer of the Commonwealth Council for Scientific and Industrial Research, gave a lecture on 'Scientific Research in Relation to Industry'.

Professor Richardson said that the demand for assistance for scientific research in agricultural problems was so great that the Council for Scientific and Industrial Research had now about 600 workers engaged in research on primary problems. He emphasized that the central aim of the national policy should be the development of primary industries to the highest attainable level and the organisation of the rural population as an important part of the political and social fabric of the nation. He went on to show that the investment which Australia had made in research had paid magnificent dividends and the improvement in production had benefited farmers, consumers, and society as a whole. So far as the future was concerned there were immense developments still to take place in Australia's primary industries.

Professor Richardson went on to show that, although primary production in Australia had expanded enormously during the past generation, there was an actual reduction in numbers now engaged in agricultural pursuits. For example, in 1913 there were 211,000 male persons engaged in agriculture, and, despite the tremendous developments since that date, the present number was only 189,000. That was mainly due to the mechanization of production. It was not in agriculture, therefore, that Australia could hope to absorb large numbers of new settlers. Migration must be definitely linked with industrialization. What was needed was a well-balanced economy which would envisage the full development of the mineral, power, forestry, fishery, and agricultural resources of the Commonwealth and the establishment of such manufacturing industries as are dependent upon them.

11TH MARCH, 1940

The Annual Meeting was held in the Society's Room, Tasmanian Museum, the President, His Excellency the Governor, presiding.

The following were elected Office-bearers and members of the Council for 1940:—Mr. E. E. Unwin was elected Vice-President in the place of Dr. W. L. Crowther, who retired under Rule 12; Dr. W. L. Crowther and Mr. A. L. Meston were elected in the places of Mr. W. H. Hudspeth and Dr. J. W. Evans, who retired under Rule 21; Mr. N. P. Booth was elected to the Council for the unexpired portion of Mr. Unwin's period, namely one year: Treasurer, Mr. S. Angel.

Mr. Walter Taylor was appointed Hon. Auditor.

It was agreed, on the recommendation of the Council, to make the following change in the hours of opening the Society's Library:—

That members should make use of the Library for reading purposes only when the Assistant Librarian is present at the following times:—Monday, 10 a.m.—1 p.m.; Wednesdays and Fridays, 10 a.m.—1 p.m., 2—5 p.m.; 7.30—8 p.m. on evenings when a General Meeting is held.

It was also suggested that, if members wished to use the Library on Saturday mornings, this might be arranged instead of a half day during the week.

Mr. H. O'May gave an illustrated lecture on 'The Ship Building and Sea Faring Pioneers of Tasmania' of which the following is an abstract:—

These pioneers played a very important part in the development of the Island State, but, as Tasmania was a penal settlement, the free colonists were not allowed to build or own vessels, and, as the vast landlocked waters at the estuary of the Derwent abounded with the black whale in the breeding season, those early settlers were forced to stand by and witness thousands of pounds worth of whale oil taken by Port Jackson and English whale ships, and they were not allowed to participate. This of course caused much discontent, and it was some years before these restrictions were removed.

Then convenient places were chosen around the foreshores, suitable bluegum trees selected, saw-pits dug, and keels, frames, planking, and fastenings of tree-nails prepared.

This Tasmanian timber proved to be second to none for shipbuilding purposes, trees could be found up to 150 feet, straight up to the first limb, this was a great advantage, as it allowed the keels, keelsons, and stringers, &c., to be cut in one length, and the breaking strain of this splendid timber was above that of English oak or teak.

The first square-rigged vessel known to be built on the shores of the Derwent was the *Campbell Macquarie*, a brig of 133 tons. She was built by Samuel Gunn for R. W. Loan, a merchant of the city, and was launched in Sullivan's Cove in 1813.

Vessels were built at New Town Bay, Rosny Point (then known as Canadian Point), Brown's River, Pittwater, Port Davey, Macquarie Harbour, Port Arthur, Bruny Island, and the Huon River, some for the flourishing whaling trade (the price for whale oil then ranged from £25 to £120 per ton), and others were engaged in inter-colonial, and quite a number for the Home trade. These little Tasmanian built vessels poked their long flying jib-booms into many ports of the world, and wherever they went they were admired, by men who understood the sea and ships, for their staunchness of construction, their model, and rig.

Amongst the builders were David Hoy, Thomas Florence, W. Maycock, Johnson, Peter De Graves, Williamson, Gray, Callaghan, C. Chessell, John Ross (who laid down the first patent slip in 1854). Perhaps the best-known was John Watson, who launched many fine vessels, amongst them the historical whaler *Flying Chudlers*, and he also taught many young Tasmanians the art of ship-building. Such past-masters as John, Alexander, and James McGregor, John Lucas, James Mackey. All these yards turned out some splendid vessels, such as the *Harriet McGregor*, *Loongana*, *Waratah*, *Oceana*, *Nautilus*, all noted for their models and speed. The largest vessel, *Tasman* (560 tons), was launched by Peter De Graves in March, 1847. Johnson, from his yard at Kangaroo Point in 1838, launched the barque *Sir George Arthur*, a vessel of about 400 tons, build for Petchey, and it was the first Tasmanian-built vessel to enter the London trade.

Callaghan built the first steamer in Tasmania. He set afloat the *Governor Arthur* from his yard in Sullivan's Cove in 1832. This little vessel was built for the Kangaroo Point ferry service.

Charles Chessell was responsible for the first ship-rigged vessel when he launched the *Maria Orr* for William Morgan Orr. This ship was built on the spot where the Shell Oil Tank now stands.

Williamson built many fine vessels. Amongst them were the *Harriet Nation* and *Margaret Brock*. John Ross, from his yard at Secheron Point, launched the *Thomas Brown* and *Isabella Brown*.

The last barque-rigged vessel built was the beautiful little *Loongana*, set afloat by John McGregor from his yard on the foreshore of the Domain in 1878.

The number of vessels built at Hobart from 1825 to 1872 was 313, with a tonnage of 19,959.

In 1919 Purdon and Featherstone launched from their yard at Battery Point the *Valmaric*, a fore and aft three-masted schooner of 256 tons.

H. McKay built, on the shore of the Channel, the three-masted fore and aft schooner *Kermadie*, 342 tons; and F. and H. Moore built and launched from Battery Point the three-masted topsail schooner *Amelia J*, 352 tons, for H. Jones and Co. This splendid little blue-gum clipper was lost with all hands on a voyage from Newcastle to Hobart in 1920.

Tasmanian seafarers were also known for their seamanship. This can be easily understood, for the island depended on them for its existence, and those little vessels kept the trade alive and the wheels of industry turning; and what a training ground for the young native-born on the broad almost tideless reaches of the Derwent. With the splendid wide stretches of land-locked waters at its estuary they could not be otherwise than expert seamen.



8TH APRIL, 1940

A meeting was held in the Society's Room on this date. Mr. W. H. Clemes presided in the absence of the President.

The following were elected members of the Society:—Ordinary Members, Miss W. M. Curtis, Mr. John Dow, Mr. A. M. Olsen; Associate Members, Mr. H. A. Winter, Mr. P. J. Bowling.

Dr. W. L. Crowther raised the question of the condition of the grave head-stones in St. David's Park, and the following motion was moved by him and seconded by Miss C. Travers, and the resolution was carried: *That members of the Royal Society recommend that action be taken by the City Council to safeguard the condition of the head-stones in St. David's Park, to have the lettering on the stones improved, and to make the head-stones more accessible for inspection by the public.*

Dr. H. D. Gordon gave an illustrated lecture on 'The Vegetation of the Beach', of which the following is an abstract:—

Sand is constantly being deposited on the beach by the sea, and as the surface dries at low tide it is blown inwards, plants and other obstacles cause it to heap up, forming sand-dunes.

Plants which grow in mobile sand must possess wide-spreading roots and runners capable of holding the sand, and must also have a vigorous upward growth to cope with the sand which is constantly being blown on top of them. In this way they build up higher and higher sand-dunes. The most efficient dune-former and sand-binder is the introduced Marram grass, but a number of native plants, such as the coast fescue, spreading sedge, and shore wattle are also effective sand-binders. Numerous other plants can establish themselves when these pioneers have brought some stability to the sand.

Often high winds will undo the work of the sand-binders and cause disintegration of the dunes, and persistent on-shore winds may keep the sand moving inland so as to cover adjacent land.

On sheltered beaches there is often a level strip of sand above high-water mark but in front of the dunes, which is inhabited by a distinct colony of strand plants, such as the sea rocket and glistening saltbush. These small plants form miniature dunes by accumulating small quantities of blown sand, but are incapable of surviving on the exposed beaches where movements and accumulation of sand are rapid.

Miss W. M. Curtis gave a paper on '*Spartina Townsendii*, its History and Economic Value in Reclaiming Tidal Mud', of which the following is an abstract:—

*Spartina Townsendii*, a grass inhabiting tidal mud, was first recorded in 1870 from the salt marshes of the South of England: ten years later it was recognized by H. and J. Groves as a distinct species. Although the plant bred true from seed, it was suggested that it might be a hybrid between *Spartina stricta*, which is indigenous to Europe, and *Spartina alterniflora*, introduced from America at the beginning of the nineteenth century.

An investigation of the floral morphology gave no clue to the origin of the plant, but the hybrid hypotheses was confirmed in 1930 by the cytological work of Huskins. He found the somatic chromosome numbers of the European representatives of the genus *Spartina* to be:—*S. stricta*,  $2n = 56$ , *S. alterniflora*,  $2n = 70$ ; *S. Townsendii*,  $2n = 126$ . Huskins therefore found *S. Townsendii* to be 'an allopolyploid derived from the doubling of the chromosome number in the original hybrid plant.'

The new species has proved a rapid and effective colonizer of tidal mud, and has spread naturally to cover scores of square miles of country throughout the salt marshes of the south of England and the north of France. It has been planted on a large scale in Holland, where the resultant stabilization of the mud and rapid rise in level of the marsh have led to a very considerable acceleration in the operations of poldering and complete reclamation of land. *S. Townsendii* has recently been introduced to Australia, where small-scale experiments are in progress in various localities.

13TH MAY, 1940

A meeting was held in the Society's Room. The President, His Excellency the Governor, presided.

Mr. B. W. Rait read a paper entitled 'A Century-Old Dictator', dealing with the life of Jorgen Jorgenson.

Born in Copenhagen in 1780, Jorgenson served as an apprentice in an English collier at the age of 14. After four years he transferred to a whaler, and made his way to Cape Town, where he joined the *Harbinger*, in which vessel he came to Australia in the year 1800. On the way out, King Island was discovered and named. In New South Wales, Jorgenson joined the brig *Lady Nelson* as second mate, and witnessed first the foundation of the first settlement on Van Diemen's Land at Risdon in September, 1803, and later the vain effort to establish a settlement at Port Phillip by Lieutenant-Colonel David Collins in October, 1803. He was on board the *Lady Nelson* during the exploration of the River Tamar in January, 1804, and in February took part in the foundation of Hobart. He left the *Lady Nelson* to join the whaler *Alexander* as chief officer, and claimed that, on a visit to the Derwent in this ship, he killed the first whale in the river. Returning to England in 1806 he crossed to Copenhagen, where he obtained command of a privateer *Admiral Juul*, in which he attacked the H.M.S. *Sappho*, and was compelled to strike his colours. He was taken to Yarmouth as a prisoner of war, and it was whilst on parole that he embarked upon an expedition to Iceland. This was in December, 1808, and on the second visit in June, 1809, he organized the dramatic coup that made him the self-styled 'Lord Protector of Iceland'. Ultimately, he was deposed, and, after many misfortunes, broke the law, and was transported to Tasmania for life, where he died in 1841.

Mr. E. T. Emmett also delivered an illustrated lecture on 'Early Days of New Norfolk', of which the following is an abstract:—

Sir John Hayes visited what is now the settlement of Hayes in 1793, and named the Derwent, Cornelian Bay, Mt Direction, and Risdon. The Rev. Robert Knopwood also visited the district in 1804, and in 1807 Lieut. Laycock, on his way from Launceston to Hobart, stopped there. Governor Macquarie named the settlement Elizabeth Town in 1811, but the real genesis of the settlement might be said to be in the deportation of Norfolk Islanders to Australia in 1803. Elizabeth Town did not progress, and the district called New Norfolk, after the Norfolk Islanders, became the town. Mr Emmett traced the history of the churches at New Norfolk and of various other places of interest connected with the growth of the settlement.

#### 10TH JUNE, 1940

A meeting was held in the Society's Room on this date. In the absence of the President, Mr. E. E. Unwin, Vice-President, presided.

Miss J. W. Richardson was elected an Associate Member.

Mr. Clemes proposed, and Dr. Pearson seconded, that Dr. W. L. Crowther and Dr. V. V. Hickman be awarded the Royal Society of Tasmania Medal. This was carried unanimously.

Mr. E. O. G. Scott gave an illustrated lecture on 'Fish and Fish-like Animals', of which the following is an abstract:—

An introductory section dealt with some of the principal lines of contemporary research on fishes, and included reminiscences of prominent ichthyologists in various parts of the world.

The main groups of fish-like animals were enumerated: their affinities were discussed, and reasons for excluding them from the Class Pisces briefly noted.

Short accounts, illustrated by lantern slides, were given of recent researches in such fields as fish locomotion (Gregory, Breder, Green, Harris); mass-psychology (Schuett, Breder, and Nigrelli); Escobar, Minahan, and Shaw); round-about path of the Fighting Fish, *Betta splendens* Regan (Beniuc); antagonism and toxicity (Ellis, James); statistical researches on North Sea fisheries (D'Arcy W. Thompson, Graham); food of *Salmonidae* (Neill); influence of pH on rate of growth (Southern); life-histories of Australian pelagic fishes (Dakin, Colefax); matroclinous inheritance in *Mollusca* (Hubbs); etc.

#### 8TH JULY, 1940

A meeting was held in the Society's Room on this date. The President, His Excellency the Governor, presided.

The Royal Society of Tasmania Medal was presented by His Excellency to Dr. W. L. Crowther and Dr. V. V. Hickman, and they replied.

Miss C. H. Wedgwood delivered an illustrated lecture on 'The Economic Life of a New Guinea People', of which the following is an abstract:—

The lecture dealt with the Island of Manam, which lies about ten miles to the east of the coast of New Guinea in Lat. 4° 30' S. The islanders live in thirteen villages along the foreshore. These are composed of a number of separate homesteads occupied by members of a single family, those of the same clan forming usually a small hamlet. Each village has its own chief (*tanepwa*), who formerly had considerable authority and still plays an important part in the social and economic life. He is always the senior male member of the clan of the original founder of the village, the other clans also have their headman, who are leaders in all clan undertakings. Inter-marriage between the villages is usual, but each village is composed of different clans and is an independent entity.

There are certain misconceptions about the economic life of primitive peoples: that the women are drudges and the men drones; that natives are by nature lazy and only work for material necessities; that there is no specialization, and hence no organization, of labour; everyone working for his own individual family, that private ownership of land and goods is unknown, a kind of communism being the custom. To show how completely these are misconceptions three types of economic activity were described: gardening, house-building and canoe-building, and overseas trade.

Each village has its own tract of bush land, which is subdivided between the clans and of which the individual men and women have rights in garden ground. Ground is cultivated for two years and then left fallow for six or seven years. The clearing is done by a man with the help of his kinsmen, and they help the women with the planting. A woman with her younger children does the day-to-day weeding in her own or her husband's garden, but he often goes with her to help. There is no true harvest since the crops cannot be stored, but are dug as they are needed. Once a year, however, a village invites a neighbouring village to a festival at which the visitors dance and hosts make large gifts of food: this is reciprocated a few days later. The exchange has no significance as trade, but is of very great social importance. Generosity with food is expected of all people: all important social occasions (births, marriages, funerals, puberty ceremonies) are marked by feasts or a distribution of food. The crops which a man and his wife grow are never consumed only by themselves and their children, they are caught up in an intricate net-work of social obligations.

There are two types of house; one built on the ground and used by a man, the other raised off the ground on piles which is the woman's domain. The latter is the more important. In building such a house a man is helped by his male kinsfolk, while his wife and female kinsfolk prepare food for the workers. Kinsmen may also help by contributing wood for the building and coconut leaves for the thatch. The hearth, made up of layers of sand, fern and plaited coconut leaf, is always set in place by the woman who is to use it—the mistress of the house.

Manam is not self-contained, and it has always had to depend on the mainland. Every man and many women have in one or more mainland villages an hereditary "trade partner" (*tava*). Only in this way was trade between normally hostile villages possible. Special, large, overseas canoes are built for the trading expeditions, and on their construction and beautification much labour is expended. Each clan has the right to build such a canoe, though the head man is spoken of as its owner, and it is he who organizes its construction and requites the workers with food and feasts. The most important canoe is that of the village chief. All the villagers, as well as his kinsmen in other villages, are expected to help build this. During the process of canoe-building, magic is made, not only to ensure that the vessel shall sail well, but also that it may attract to it the wealth of the mainland villages so that the trading expeditions may be prosperous.

European and native attitudes towards work and ownership of property are sufficiently different to lead to misunderstanding and conflict. To the native most work is a social activity and is creative with a definite emotional tone. The co-operative method of work and the custom of gift exchange serve to bind the community together, and have therefore much more than a merely economic significance. Reciprocity is the basis of all social relations.

12TH AUGUST, 1940

A meeting was held in the Society's Room on this date. Mr. W. H. Clemes presided in the absence of the President.

Miss J. Munro Ford was elected a member of the Society.

Mr. Leonard Cerutti delivered a lecture on 'Francis Bacon', of which the following is an abstract:—

Mr. Cerutti suggested that it might be profitable for members to study the works of Francis Bacon. There is a distrust of science exhibited in some quarters to-day, and free scientific thought is being attacked in the interests of state policies in Europe, so that contemplation of the doctrines of this man, who 'rang the bell which called the wits together', is salutary. 'His philosophical works have moved the intellects that have moved the world.'

The literary works of Francis Bacon display his unemotional mind, the poverty of his moral feelings, and his lack of warm human affection, but these defects scarcely detract from his contributions to scientific philosophy. He stood at the beginning of the modern scientific era, and in his two great works, *The Advancement of Learning* and the *Novum Organum*, he crystallized advanced thought of his time and established a basis for the work of the natural philosophers of the 17th century. He preached the doctrine of hard work in science; he insisted upon the danger of authority to scientific truth, and he emphasized the essential nobility of scientific investigation.

#### 9TH SEPTEMBER, 1940

A meeting was held in the Society's Room on this date. The President, His Excellency the Governor, presiding.

The following were elected members of the Society:—Professor J. B. Cleland, Mr. E. F. Fricke.

Mr. A. M. Olsen gave a paper entitled 'New Tasmanian Orchids'.

Mr. Olsen dealt with *Chiloglottis pectinifera*, Rogers (Alpine Bird Orchid)—a slender glabrous plant about 8-18 cm high. Leaves basal 2, oblong-lanceolate on long petioles. Flower solitary, greenish-bronze or wholly dark-prune. Lateral sepals linear-lanceolate, recurved, connate at base. Dorsal sepal spatulate-acuminate, about same length as lateral sepals. Petals lanceolate, wider than sepals but about same length. Labellum oblong, shorter than sepals, slightly recurved about the middle of lamina. Calli dark-purplish. One large crescentic sessile callus in middle line in advance of all others, a large bi-lobed stalked callus about midway between this and lamina base; and various small stalked calli around. Column winged above; another blunt, stigma circular.

This species is easily distinguished from all other known forms by the oblong canoe-shaped labellum.

It is known in Victoria only from Cravensville, Tallangatta Valley, N.E. Victoria, where it was discovered by Mr. A. B. Braine, the local school-master. It is fairly numerous in this locality. Found in Tasmania at Mt. Barrow, where also it is reported as abundant. The Collector is Mrs. Pearl Messmer, of Lindfield, Sydney, N.S.W.

Flowering period: September to November.

Mr. A. L. Meston gave an illustrated lecture on 'The Culture of the Tasmanians', of which the following is an abstract:—

The first group of slides dealt with the stone implements deliberately shaped for special service as tools. Many of these show skilful workmanship and reveal that the Tasmanians had made considerable advance in the technique of stone tool production. The lecturer attempted a classification of the implements, based on a very large number of specimens. The most abundant specialized form is the scraper with a snout, a tool which bears a marked resemblance to the *grattoir à museau* found in the upper levels of the Western European culture known as Aurignacian. Another abundant specialized implement is the point. Many of the specimens shown on the slides had delicate narrow secondary flaking, the work of skilled craftsmen. Concave scrapers, no doubt used as spoke shaves for smoothing the wooden spears and waddies, form another abundant group. Side scrapers, in which the cutting edge formed along the side of the flake is slightly convex, are well adapted as skinning tools. Other forms shown were high-backed or keeled scrapers, a highly specialized form of core scraper, and end scrapers. Several slides showed combination implements, and the characteristic oblique-angled striking platform of the Tasmanian lithic culture.

Besides these flake tools the lecturer showed the highly interesting and exceedingly primitive pebble choppers, known to science as the Sumatra type. Similar core implements may be collected in great numbers along the whole length of the east and south-east coast of Australia.

The third group of slides illustrated the bone implements used by the Tasmanians. These were of two distinct kinds, points and spatulas. Some have apparently been used as flaking tools, others for basket-weaving, though once again the use of these tools, unfortunately, is mainly conjectural.

An interesting slide was that depicting a basket made by Truganini, the last of the Tasmanians, for Miss Dandridge, and now in the lecturer's possession. Attention was drawn to the primitive basket weave.

Other slides dealt with the stone carvings of the Tasmanians at Devonport, Mt. Cameron West, and Trial Harbour; the small carefully shaped circular stone discs of unknown use, so frequent on West Coast middens, mill-stone, with well worked peripheral edges covered with red ochre pounded to form a raddle for the hair; hammer-stones of various shapes and sizes, and hut sites on the West Coast.

The lecturer also showed a unique skull drinking-cup, found on a midden close to a spring of sweet water at Port Sorell on the North West Coast. This is formed of a human skull top, which has been carefully cut into a drinking bowl, and has much similarity with the two skull ceremonial or drinking bowls from the Magdalenian layer in the great grotto of Placard in France.

#### 7TH OCTOBER, 1940

A meeting was held in the Society's Room on this date. The President, His Excellency the Governor, presiding.

Mr. Gregory Mathews, C.B.E., F.R.S.E., M.B.O.U., &c., author of the *Mono-graph on the Birds of Australia*, lectured before the Society and dealt with the preliminary work involved in obtaining material upon which his twelve volumes of the *Birds of Australia* were based. In the first place he organized observers and collectors throughout the Commonwealth, having at one time as many as twelve expeditions simultaneously in the field. Upwards of 120,000 birds' skins were obtained. These had to be carefully examined for purposes of identification, and all the information regarding them had to be tabulated. At the same time that this work was proceeding he began a quest for historical works bearing upon Australian birds, and as a result of this many works of great value were discovered. The lecturer went on to speak of bird migration. A great deal still remains to be done regarding Australian bird migration, and it was important that migration routes should be determined as soon as possible.

In his introductory remarks the President referred appreciatively to Mr. Mathews' generous action in presenting to the Commonwealth Government his entire library dealing with Australian birds.

#### 11TH NOVEMBER, 1940

A meeting was held in the Society's Room on this date. Mr. E. E. Unwin presided in the absence of the President.

Mr. D. Daish was elected a member of the Society.

The following papers were laid on the table and taken as read:—

- (a) Consett Davis: 'Ecology of the S.W. Tasmania'.
- (b) J. W. Evans: 'The Morphology of *Tettigarcta tomentosa* White (*Homoptera, Cicadidae*)'.

- (c) R. F. Cane: 'Studies in Tasmanite Shale Oil'.
- (d) P. B. Nye: 'Tertiary Marine Rocks of Far N.W. Districts of Tasmania'.
- (e) F. M. Carpenter: 'A New Genus of Mecoptera from Tasmania'.
- (f) A. B. Edwards: 'On a Remnant of a Stripped Peneplain of Palaeozoic Age at Mt. Sedgwick in Western Tasmania'.
- (g) E. O. G. Scott: 'Observations on Fishes of the Family Galaxiidae. Part III'.
- (h) W. H. Nicholls and A. M. Olsen: 'Additions and Corrections to the *Orchidaceae* of Tasmania'.
- (i) J. Pearson: 'The Heart and Great Vessels in the Marsupialia'.
- (j) J. Pearson: 'The Reproductive System in the Marsupialia'.

Mr. H. T. Parker delivered a lecture entitled 'Can Animals Think?', of which the following is an abstract:—

We are inclined to assess an animal's capacity for thinking by the aptness or the complexity of its behaviour. But in all animals behaviour is to a great extent innately determined, and does not call for thinking at all. Even actions which are learned do not of necessity originate in deliberation, they may be no more than modifications brought about by particular elements in the environment.

The question cannot well be discussed without some idea of what thinking implies. Even in its most elementary forms, thinking goes beyond immediate experience to a realization of meaning. When thought governs action, it does so by ideal construction, that is, by living through in imagination an experience which may later be lived through in fact. This is planning or forethought. One may not admit evidence for thinking in animals unless this element of forethought is present.

The cases of 'Clever Hans' and the Elberfeld horses are instances of learned reactions to barely perceptible signals, and do not involve thinking at all. The homing powers of dogs or other animals are instinctive and not rational. The hoarding tendencies exhibited in many animals, from squirrels to ants, if ascribed to thinking, could only be called stupid. It is only when we come to higher animals—dogs, cats, rats, racoons—that there is any evidence of true thought. This is most marked in the case of chimpanzees, as Kohler's experiments disclose.

The main instrument of human thought is language. The fact that no animals possess language except the elementary language of emotion restricts their thinking to a very rudimentary type.

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## Northern Branch

### Annual Report, 1940

Meetings of the 1940 Session, other than the Annual Meeting and Public Lecture and the July Meeting (Demonstration at Commonwealth Health Laboratory), were held in the Lecture Room at the Queen Victoria Museum and Art Gallery. The extended programme of meetings initiated last year was maintained.

20TH MAY, 1940

#### *Annual Report and Public Lecture*

The Annual Meeting for 1940 was held in the class-room, Public Library, at 7.30 p.m.

Mr. F. Smithies presided. The following were elected officers for 1940:—  
President: Mr. F. Smithies.

Council: Mr. F. Smithies (Chairman), Mr. F. Heyward, Hon. Tasman Shields, Mr. W. R. Rolph, Mr. R. S. Padman, Mr. J. R. Forward, Mr. D. V. Allen, Mr. J. E. Heritage, Dr. R. A. Scott.

Hon. Secretary: Mr. E. O. G. Scott.

Hon. Auditor: Mr. R. S. Padman.

The Annual Report and the Statement of Accounts, which showed a credit balance of £29 17s. 1d., were read and adopted.

The Annual Meeting was followed, at 8 p.m., by a public lecture, 'Romance of Tasman's Peninsula' by Rev. Lewis E. Barnard. The lecture was given in the Public Library Hall.

Mr. Barnard first gave a general account of the history of Tasman's Peninsula. The natural advantages of the Peninsula as the site for a penal colony were pointed out, and consideration was given to the methods of guarding Eaglehawk Neck devised by Capt. O'Hara Booth.

While the story of Tasman's Peninsula is inevitably largely the story of the penal system in Tasmania from the date of the foundation of Port Arthur, the lecturer chose to dwell chiefly upon the romantic, rather than the sordid, aspect of the period of occupation. Features dealt with included the signalling system, defence of the Neck, Martin Cash and his two escapes from Port Arthur, the history of the Church, the convict railway, and Commandant's house.

All phases of the subject were abundantly illustrated by means of lantern slides, a large number of the pictures shown depicting scenes at the settlement during the period of occupation.

24TH JUNE, 1940

The President, Mr. F. Smithies, presided.

Mr. E. O. G. Scott gave an illustrated lecture on 'Recent Researches on Fishes'.

Mr. Scott first touched briefly on the increasing differentiation of knowledge with the advance through the ages of science, and drew attention to the degree of specialisation that now characterises even restricted fields in biology. Some reminiscences of prominent ichthyologists in various parts of the world met by the lecturer on a recent tour were given, and reference made to some of the more important and more interesting researches carried out by them.

The introductory talk was followed by the showing of a series of lantern slides to illustrate recent researches on such subjects as fish locomotion; mass psychology; round-about paths, and the teaching of food-routes to fish; the influence of pH on growth, Australian investigation on life-history of pelagic fishes, influence of physical and chemical factors of the environment, matroclinal inheritance in *Mollusca*; and allied topics.

The lecture was followed by a discussion, in which Mr. Holmes, Mr. Fricke, Mr. Evershed and others participated.

#### 15TH JULY, 1940

The President, Mr. F. Smithies, presided.

Instead of the usual lecture, the meeting for July took the form of a demonstration by Dr. R. Y. Mathew, Medical Officer in Charge Commonwealth Health Laboratory, of the work of that institution.

Dr. Mathew gave a general account of the work of the Laboratory and indicated something of the scope and nature of its routine work. He had prepared about a dozen exhibits designed to show, by means both of actual specimens and explanatory notes, some standard methods of diagnostic procedure in the case of such diseases as tuberculosis; diphtheria; typhoid, and allied fevers; pernicious anaemia; several venereal diseases; etc. Associated with these exhibits were others illustrating various aspects of the investigation of the state of the blood. At the conclusion of Dr. Mathew's introductory talk, occupying about three-quarters of an hour, members circulated freely throughout the Laboratory, and inspected at leisure the interesting exhibits prepared for their examination.

As an addendum to his general remarks, Dr. Mathew briefly described, and showed examples of, biological products prepared at the Commonwealth Serum Laboratories, Melbourne.

An interesting discussion, in which the President, Mr. A. E. Evershed, Major Smith, Mr. F. J. Heyward, and the Secretary participated, followed the conclusion of Dr. Mathew's address. After members had finished their examination of the exhibits, demonstrations were given of the use of various types of apparatus employed in the institution's work, and a general tour of the Laboratory was made under the guidance of the lecturer.

#### 19TH AUGUST, 1940

The President, Mr. F. Smithies, presided.

Mr. J. D. Valentine gave a lecture on 'Flax'.

Mr. Valentine gave a general description of the Flax Plant, *Linum*, and spoke of its importance as a source of oil and fibre—world-crop covers 19,000,000 acres, of which more than two-thirds is grown for seed, from which is obtained linseed oil. Attention was drawn to the fact that a special variety of the common flax, *Linum usitatissimum*, is used for the fibre of commerce.

The speaker then traced the history of flax and of the production of linen from the earliest times, giving some account of the important part it played in various civilisations, such as the Egyptian, Phoenician, Roman, and Grecian. Special attention was paid to the story of the flax industry in England and Ireland.

After enumerating some of the uses in wartime (for manufacture of 'planes, canvas, cordage, etc.), he spoke of the shortage of raw material due to the cessation of exports from Russia (which produces more than four-fifth of the world's supply). An account was then given of the scheme, sponsored by the British Government, for the planting in Australia of 20,000 acres (Tasmania's share 1,300 acres), with 400 tons of seed from England.

Mr. Valentine then traced in detail the process of manufacture of linen to the weaving stage; and afterwards proceeded to discuss the agricultural side of the problem, with detailed observations on the conditions and methods of growth, time of planting, suitable soils, fertilizers, methods of harvesting, etc.

The lecture was followed by a discussion in which Mr. Rolph, Mr. Smithies, Mr. D. V. Allen, and Mr. Evershed took part.



16TH SEPTEMBER, 1940

The President, Mr. F. Smithies, presided.

Dr. A. N. Lewis, who was welcomed to the Northern Branch by the President, gave a lecture on 'Tasmanian Physiographical History'. Before dealing with the subject of his talk, Dr. Lewis expressed pleasure at being present as a representative of the Council of the parent Society, and spoke of the helpful effect of interchange of lecturers between Hobart and Launceston in maintaining and extending general reciprocity between the parent body and the Branch.

Dr. Lewis then gave an illustrated lecture on 'Tasmanian Physiographical History'.

Dr. Lewis introduced his subject by briefly considering the importance of the environment to the individual and community. With the aid of an extensive series of lantern slides, depicting geologically interesting localities in all parts of the State, he gave an account of general physiographical principles, and pointed out the chief factors concerned in shaping the configuration of the landscape. Special attention was paid to the work of rivers, and the mode of action of this agency was dealt with in some detail. Consideration was also given to the effects of earth-movements in causing elevation and depression of the land; and to the various factors constantly at work in shaping the landscape.

After thus laying down some general principles, the speaker proceeded to trace in outline the story of the moulding of Tasmania. Points that received special attention included the formation of the present plateaux (now standing at a height of 3000-4000 feet), at, or near, sea-level; the comparatively recent elevation of these regions; the present stage of erosion; the partial rejuvenation of rivers such as the South Esk; the sharp line of demarcation between the older strata of the West Coast and the newer formations of the Midlands; the effects of pressure from the south-west; the history and nature of recent lava-flows; the order of deposition of various strata; the comparatively late intrusion of the diorite; varves on the West Coast; moraines; and the influence of ice-action generally.

Dr. Lewis having invited questions, there was an interesting discussion at the conclusion of the lecture.

21ST OCTOBER, 1940

The President, Mr. F. Smithies, presided.

Mr. H. J. King screened a series of Natural History Films, prepared in connexion with the educational programme of the Queen Victoria Museum, and gave a short address on 'Colour Photography'.

Mr. King briefly outlined the history and development of the production of camera-pictures in colour, and described the different principles adopted in the various commercial methods. The Kodachrome process, which was used in the present undertaking, was dealt with in some detail, and the various stages of processing the exposed film were explained. He concluded his address by reviewing the circumstances in which the films were made and by recalling some of the interesting incidents associated with their preparation. The Museum National History Films were then projected by Mr. King, who delivered a running commentary on them. An additional short film on Tasmanian Natural History was next screened, and was followed by one of Mr. King's own films depicting the Cradle Mountain Reserve.

At the conclusion of the meeting, supper was served in the Historical Art Gallery.

#### COUNCIL MEETINGS

Council Meetings were held on the 2nd May, 18th June, 18th July, 5th August, 2nd September, 4th October, 16th December.





PAPERS AND PROCEEDINGS  
OF  
THE ROYAL SOCIETY  
OF TASMANIA

FOR THE YEAR

1941



Edited by  
JOSEPH PEARSON

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PUBLISHED BY THE SOCIETY  
The Tasmanian Museum and Art Gallery, Hobart

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1942

*Price: Ten Shillings*



# The Royal Society of Tasmania

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## Papers and Proceedings, 1941

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## A Tasmanian Stone Implement made from Bottle Glass

By

NORMAN B. TINDALE

(Read 13th October, 1941)

### PLATE I

In 1938, Mr. F. D. Maning found a Tasmanian implement at Kempton, Tasmania, which had been made from the base of a glass bottle of old-fashioned type.

The interest of this particular specimen is in the form of which it has been made to take. It is an irregularly shaped notched scraper 6.5 cm. in diameter with three indentations, the arc of each of which has a radius of approximately 6 mm. The implement has had much use, and, owing to the relative softness of the material, the cutting edges show abrasion marks due to friction of the glass against the wood which it has been used to trim. The diameter of the notch seems to indicate that it was used for the preparation of a spear or a thin, club-like object. The abrasions also tend to suggest that part of the work must have been done at the extremity of some weapon, like a club, where the wood is tapering to a point or is rounded off.

The important abrasions appear principally on what corresponds to the inner face (or flake surface) of the implement, and examination of their directions gives rather definite indications of the likely method of holding and using the implement. Indeed, it suggests that the inner face was opposed to the work and that the implement was drawn towards the worker.

The few first-hand observations on record of the tool-using methods of the Tasmanians have indicated to us the likelihood that they used their stone implements without handles and without the aid of gum-hafting. The present example indicates that the stone itself was held very flatly against the material which was being worked, and that, in consequence, even notches which had become obtuse through constant re-sharpening could be used and be made to function efficiently.

Plate I, figs. 1 and 2, gives two views of the implement. Fig. 3 suggests the manner in which the implement was held while in use. The principal abrasive marks are indicated as they appear in association with two of the notches. The directions of abrasions suggest also that the implement was held at one time in the right hand and on another occasion in the left, the abrasions on the left-handed notch are rather less marked than those of the other. The third notch shows no signs of such abrasion, and may indeed have been freshly retrimmed just before the implement was abandoned.

Abrasions on the outer or worked surface seem to have been caused by rubbing, and suggest the possibility that the surface of the work may have been smoothed with this implement.

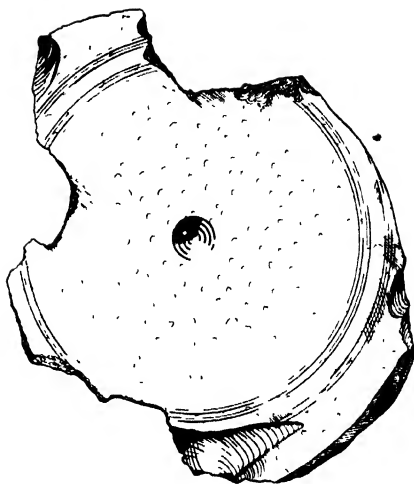


The implement is of well-defined Tasmanian type, and the material used dates the making of it to somewhere within the last two centuries. It would be of interest if it could be ascertained whether the glass is such as was used in English bottles of the early nineteenth century or whether it could be attributed to Dutch or other voyages of still earlier times.

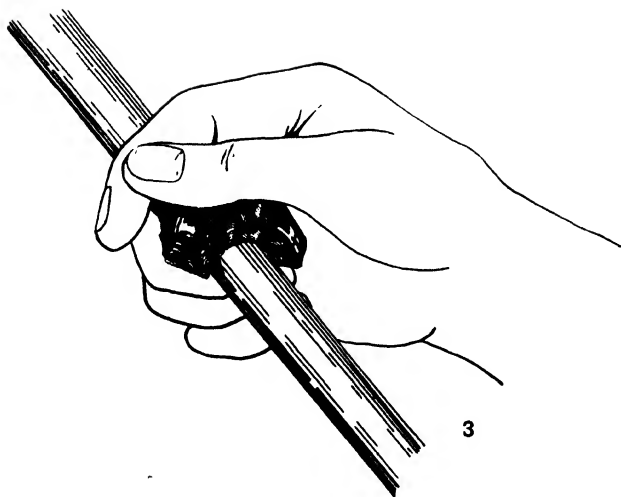
The specimen has been kindly lent by Mr. F. D. Maning to the Tasmanian Museum at Hobart.



1



2



3



## Some Tasmanian Palaeozoic Corals

By

DOROTHY HILL

*University of Queensland*

(Read 13th October, 1941)

### PLATE II

Palaeozoic corals from several Tasmanian localities are described, including two new species, and the ages they indicate are discussed.

#### UPPER ORDOVICIAN OR SILURIAN

##### Limestone at the head of the Nelson R.

*Plasmoporella* sp. indicates that the age of this limestone is within the range of the genus—Upper Ordovician, Valentian, Niagaran.

##### Chudleigh Limestone, Liena, Mersey R.

*Favistella cerioides* sp. nov. resembles the Upper Silurian (Ludlow) *Favistella gothlandica* (Edwards and Haime) more closely than the Upper Ordovician species from North America. *Favosites marginatus* sp. nov. does not resemble closely any species described from the Silurian, but comparisons may be made with a rather imperfectly known form from the Upper Ordovician of North America. *Plasmoporella* cf. *convexotabulata* Kiaer is identical morphologically with the Upper Ordovician or Lower Silurian species from the Baltic and China. *Halysites ?chillagoensis* Etheridge has been recorded by Etheridge (1904, p. 38), but has not been re-studied. Thus the age of the Chudleigh limestone at Liena cannot yet be fixed more narrowly than Upper Ordovician or Silurian.

#### SILURIAN

##### Gordon R.

*Hercophyllum shearshyi* (Sussmilch) and *Entelophyllum* sp. occur in the limestone on the Gordon R.; the former species occurs in beds which are Upper Wenlock or possibly Lower Ludlow at Yass, N.S.W., and the latter is very close to one species from these same Yass beds and to another from the Wenlock and Ludlow of Europe. The age indicated for this limestone on the Gordon R. is thus Upper Wenlock or Lower Ludlow.

## SILURIAN OR POSSIBLY DEVONIAN

## Blue-grey micaceous shale, yellow weathering

*Pleurodictyum megastomum* M'Coy occurs in this shale, in specimens without locality labels. It is known from the ?Lower Ludlow shale above the limestone near Bowning, N.S.W., and from the Lower Devonian of New Zealand, and thus indicates a similar age for the Tasmanian shale.

## Zeehan

*Pleurodictyum* sp., which is probably *P. megastomum*, has been recorded from Zeehan (Etheridge, 1896, p. xlii, pl. i, fig. 1) and thus suggests that Ludlow or Lower Devonian beds occur here. From Zeehan I have an unidentifiable Streptelasmid, and, from the Montagu Mine, an internal mould of an unidentifiable *Favosites* sp., with an external mould of an unidentifiable solitary turbinate Rugose coral, in a blue-grey leached shale. Two moulds of similar solitary corals in blue-grey shale are from an unknown locality.

## Point Hibbs

*Heliophyllum ?chillagoense* (Etheridge) resembles the cerioid Middle Devonian *H. tabulatum* (Quenstedt) from the Eifel, and *H. confluent* Hall from the U.S.A., and may thus indicate a Devonian age. However, the species described by Etheridge from Chillagoe, Queensland, was regarded by him as Silurian because *Halysites* occurred in the same great belt of limestone. But Weissermel (1939, p. 104) has lately described *Halysites* from the Lower Devonian (Gedinnian) of the Bosphorus. At Point Hibbs our specimen is associated with *Favosites ?bryani* Jones, a species which occurs elsewhere in the ?Lower and Middle Devonian of N.S.W. and the Lower Middle Devonian of Queensland. Although the Point Hibbs limestone has previously been regarded as Silurian, it is thus possible that it may be Devonian.

The Devonian *Favosites goldfussi* d'Orbigny is probably represented by three specimens whose matrix and preservation are similar to those from Point Hibbs, but which have no locality labels.

## SYSTEMATIC DESCRIPTIONS

## MADREPORARIA RUGOSA

## Family ENTELOPHYLLIDAE Hill, 1940

Genus *Entelophyllum* Wedekind, 1927, p. 22

*Entelophyllum*, sp. (Pl. 2, figs. 1a, b)

*Material.* A fragment (F 4195, Australian Museum) embedded in a grey crinoidal limestone from the Gordon R., Tasmania. Silurian.

*Description.* The fragment is of two corallites, in part cylindrical and in part in contact and cerioid, the more complete corallite being 13 mm. in diameter in one section and 16 mm. in a section 13 mm. higher. There are 38 major septa which extend almost to the axis, and there rotate slightly, leaving an axial space about 2 mm. in diameter, and 38 minor septa extending just over half way to the axis. Both orders have a few carinae, either opposite or alternate, near the inner margin of the dissepimentarium, where they are also somewhat dilated. The

dissepiments are small, frequently geniculate in cross-section, and are rather globose in vertical section. The tabulae are incomplete, and consist of tabellae arranged in three series; those of the outermost and axial series are sagging, but the intermediate series is of highly arched plates capping one another.

*Remarks.* The specimen is closer to the genotype, which is from the Wenlock and Ludlow of Europe, than to any other of the described species, but it differs from the genotype in the slight dilatation and carination of the septa. It is quite close to *E. latum* Hill (1940, p. 413) from the Wenlock or Ludlow of Glenbower, N.S.W., but *E. latum*, like the genotype, is without carinae.

The age indicated is Wenlock or Ludlow.

The family and genus have already been discussed (Hill, 1940, p. 410; Hill and Jones, 1940, p. 188) in connection with their Australian representatives.

### Family FAVISTELLIDAE Hill, 1939,

#### Genus *Favistella* Hall, 1847, p. 275

#### *Favistella cerioides*, sp. nov. (Pl. 2, figs. 2a, b)

*Holotype.* F 5487 (Australian Museum 717), Chudleigh limestone, Liena, Mersey R., Tasmania. Upper Ordovician or ?Silurian. On the label the locality is written 'Sena'.

*Diagnosis.* Cerioid *Favistella* with corallites about 5 mm. in diameter, about 18 major septa, short minor septa, and slightly domed or horizontal, close tabulae.

*Description.* The corallum is cerioid; the corallites are unequal, varying from 1 mm. to 7 mm. in diameter, the average being about 5 mm. Increase is intermural. The common wall between two corallites may be 0.75 mm. thick. It contains a median dark line, and the stereozone on each side of this has been formed by the lateral dilatation of the bases of the septa. There are 18 smooth-sided and rather flexuous thin major septa, extending to or almost to the axis, and 18 very short lamellar minor septa alternating with them. There are no dissepiments. The tabulae are complete, slightly domed, the domes sometimes sagging at the axis, or horizontal, about 10 in 5 mm.

*Remarks.* The corallites are larger, and there are more septa than in the American Upper Ordovician species; but are similar to those of *Favistella gothlandica* (Edwards and Haime, 1851, pl. xiv, fig. 2) from the Silurian of Gotland. Our species differs from the latter however in the closer spacing of the tabulae. *F. kassariensis* (Dybowski; Weissermel), from the Silurian of the Baltic States, has very highly domed tabulae with upturned edges, and thus differs from our species. Lindstrom (1888) lists *Columnaria gothlandica* Edwards and Haime from *f.* beds equivalent to the Lower Ludlow.

The family and genus have already been discussed (Hill, 1939, p. 241) in connection with their Australian representatives.

### Family HELIOPHYLLIDAE

#### Typical Genus: *Heliophyllum* Hall MS. in Dana

Rugose corals in which the septa are carinate, with vertical carinae either opposite or alternate; the septa are long, and extend unequally and rather flexuously towards the axis, sometimes being thickened in the tabularium; the tabular floors are horizontal or slightly concave or domed, and are usually of tabellae; the dissepiments are small and globose.

**Remarks.** This family is represented in the Couvinian of the Eifel by *Ceriophyllum* Wedekind, which (see below) is probably, a synonym of *Heliophyllum*, and in the Hamilton of U.S.A. and Canada by *Heliophyllum* Hall. The forms placed in *Ceriophyllum* by Wedekind differ from *Heliophyllum halli* in having their septal carinae alternate on each side of the septum instead of opposite, and in having the structure of their tabularia rather more open, with the tabular floors predominately domed, instead of almost equally horizontal or concave or domed. The family may have been derived from the Silurian *Entelophyllidae*. Both have carinate septa and a wide tabularium, but in the *Entelophyllidae* the tabular floors are almost constantly domed, with axial insinkings, while in the *Heliophyllidae* the tabular floors are less regular and may be domed or sagging. Cross-bar carinae are common in the *Heliophyllidae*, but are not known in the *Entelophyllidae*.

### Genus *Heliophyllum* Hall MS. in Dana

*Heliophyllum* Hall MS in Dana, 1848, p. 356; see Lang, Smith and Thomas, 1940, p. 66.

*Ceriophyllum* as *Keriophyllum* (sic) Wedekind, 1923, pp. 27, 34; genotype, *C. heiligenstein*; Wedekind, 1923, p. 34; text-figs. 3a, b on p. 27. Lower Middle Devonian, Heiligenstein, the Eifel, Germany.

**Genotype.** *Heliophyllum halli* Edwards and Haime, 1850, p. lxi (see Lang, Smith and Thomas, loc. cit.), Middle Devonian, Hamilton group: Moscow, York and Seneca Lake, New York, U.S.A.

**Diagnosis.** Simple or compound Rugosa with long septa with vertical carinae either opposite or alternate, with major septa extending flexuously in the tabularium almost to the axis, and with small dissepiments, and flat, gently domed or sometimes also slightly concave, tabulae.

See remarks under family.

### *Heliophyllum chillagoense* (Etheridge)

*Cyathophyllum chillagoensis* Etheridge, 1911, p. 4, pl. D, figs. 1, 2, Silurian [?], Chillagoe, Queensland.

**Diagnosis.** Cerioid *Heliophyllum* with alternate carinae and close, domed tabulae.

### *Heliophyllum ?chillagoense* (Etheridge). (Pl. 2, figs. 3a, b)

**Material.** One specimen in the collection of the Geological Survey of Tasmania, from Point Hibbs.

**Description.** The corallum is cerioid, the corallites being unequal, up to 18 mm. in diameter, the average being about 15 mm. New corallites probably arise by peripheral increase, as they tend to have circular walls. There are about 24 major septa extending almost to the axis, slightly flexuous in the tabularium, and 24 minor septa extending two-thirds of the way to the axis; both orders may be dilated in the dissepimentarium, and both are carinate with carinae perpendicular to the inclination of the dissepiments, and alternate on either side of the septum. The dissepiments are small in the inner parts, but larger towards the periphery; their inclination is towards the axis in the inner parts, but gently towards the periphery in the peripheral region. The area of divergence is also shown in the traces of the septal carinae in median vertical section of the corallite. The tabulae are incomplete and very close, the tabular floors being horizontal or slightly domed.

**Remarks.** The specimen appears to differ from *Heliophyllum chillagoense* only in having thicker septa, and may indeed belong to this species. The North Queensland holotype has been regarded as Silurian, because of the occurrence of *Halysites* in the same great limestone belt. But Weissert (1939, p. 100) has described

species of *Halysites* from the Gedinian (Lower Devonian) of the Bosphorus. Because of this Chillagoe anomaly, the Tasmanian specimen cannot be regarded as reliable as an indicator of age. *Billingsastraea billingsi nevadensis* Stumm (1937, pl. 55, fig. 9), from the Lower Middle Devonian of Nevada, U.S.A., differs from our species in being astraeoid, but its internal structure is very similar. In its alternate carinae our specimen resembles the European Couvinian *H. tabulatum* (Quenstedt) rather than the Hamilton American *H. confluent* Hall.

#### Family PYCNACTIDAE Hill, 1940

#### Genus *Hercophyllum* Jones, 1936b, p. 53

##### *Hercophyllum shearsbyi* (Sussmilch). (Pl. 2, fig. 4)

*Cyathophyllum shearsbyi* Sussmilch (ex Etheridge MS), 1914, fig. 143, facing p. 44 Limestone Ck., Bowring District. Silurian.

*Hercophyllum shearsbyi* (Sussmilch) Jones, 1936b, p. 54, pl. v, figs. 1a-g; pl. vi, figs. 1a-g, pl. vii, figs. 1h, 1, 2.

*Remarks.* A partly beekitised specimen (F 4211, Australian Museum), from the Gordon R., is referable to this species, which with its genus and family has recently been fully discussed (Hill, 1940, p. 401).

#### UNIDENTIFIABLE RUGOSA

##### External moulds

A fragment 20 x 20 mm. of an external mould of a solitary, turbinate Rugose coral, showed well-marked longitudinal striation and transverse growth rings. It was preserved in a leached blue-grey sandy shale from the Montagu Mine, Zeehan.

Two other fragments, G1 and G2 of similar external moulds, in a blue-grey shale one 30 x 30 mm., of solitary, turbinate Rugose corals, also showing marked longitudinal striation, are without locality labels.

##### Streptelasmid

A thin section was made of a solitary, trochoid Rugose coral softened by weathering, in a blue-grey shale from Zeehan; it showed 30 major septa with 30 alternating ragged minor septa of unequal length, and no dissepiments, at a diameter of about 13 mm. The corallum was rather compressed (F 37801, Australian Museum). It is probably a Streptelasmid, and may be the species giving the moulds described above. It is no safe indication of age, Streptelasmiids being known from the Upper Ordovician to the Middle Devonian.

#### MADREPORARIA TABULATA

#### Genus *Pleurodictyum* Goldfuss

##### *Pleurodictyum* Goldfuss, 1829, p. 113

*Genoholotype.* *P. problematicum* Goldfuss, 1829, p. 113, pl. xxxviii, figs. 18a-g. Lower Devonian, Eifel District and Nassau, Germany.

*Diagnosis.* Massive corals with thick walls pierced by mural pores, and with septa represented by low ridges with one or more rows of low spines; the calical floors are frequently furnished with small spines. The genotype usually has a worm cast through it.



*Remarks.* The genotype is known only in casts in sandstone; and, from the topotypes before me, I cannot be sure that tabulae were present. Lang, Smith, and Thomas (1940, p. 102) have considered with Hall and others that *Michelinia* de Koninck and its subgenera are synonymous with *Pleurodictyum*, and these genera are tabulate. The distinction between them and thick-walled *Favosites* has not yet been made clear, and the whole group is in need of revision. Nicholson's (1879, p. 149) researches on an American species he regarded as a *Pleurodictyum* with its own tissues preserved, showed that it possessed intramural canals in addition to mural pores. He observed that intramural canals were not present in *Favosites*, but were known in *Columnopora* and *Lyopora*. The internal moulds of *P. problematicum* which I have studied, however, give no indication of the presence of intramural canals.

***Pleurodictyum megastomum* M'Coy. (Pl. 2, fig. 5)**

*?**Pleurodictyum megastomum* M'Coy, 1867, Upper Silurian, Upper Yarra District, Victoria. *Nomen nudum*.

*Pleurodictyum megastomum* Dun, Chapman, 1921, p. 216, pl. ix, figs. 4-6: *quo vide* for list of records and localities.

*Diagnosis.* Low, hemispherical or explanate *Pleurodictyum* with corallites up to 10 mm. in diameter, average about 6 mm., each with about 25 low septal ridges studded with one or more series of low spines; the calical floors have irregularly arranged low spines.

*Remarks.* This Australian Upper Silurian (Ludlow?) and New Zealand Lower Devonian species is known only from moulds. It has already been adequately described, particularly by Foerste (1888, p. 132, pl. xiii, fig. 22) and Shirley (1938, *Q.J.G.S.*, p. 463). Two internal moulds in a yellow-weathering blue-grey shale with mica are in the collection sent from Tasmania, but their locality is not stated. They are labelled S10 and 7 11. One is 40 mm. in diameter and the other 30. The smaller shows the septal ornament well, and is figured herein (pl. 2, fig. 5). They indicate the Upper Silurian or the Lower Devonian. A third specimen in a grey-blue shale, also without locality, shows two poorly preserved specimens with corallites the same size as the others. The specimen figured from Zeehan by Etheridge (1896, pl. i, fig. 1) might well be this species.

## Family FAVOSITIDAE

### Genus *Favosites* Lamarck

***Favosites bryani* Jones**

*Favosites bryani* Jones, 1937, p. 96, pl. xv, figs. 3-6, Lower Middle Devonian, Taemas: Hill and Jones, 1940, p. 190, pl. v, figs. 2a, b, ?Lower Devonian, Molong District.

*Diagnosis.* *Favosites* with corallites about 1 mm. in diameter, moderately thick-walled and polyhedral, with long, slender, sharply-pointed septal spines, sometimes opposite, one row of circular mural pores, and fairly numerous tabulae, which are mostly complete.

*Remarks.* A specimen (pl. 2, fig. 6) from Point Hibbs appears to belong to this species; its spines are, however, more horizontal than inclined. It suggests a Lower or Middle Devonian age for the Point Hibbs beds.

**Favosites goldfussi d'Orbigny**

*Favosites goldfussi* d'Orbigny, Jones, 1936a, p. 19; Devonian, the Eifel.

**Diagnosis.** *Favosites* with corallites 2-2.5 mm. in diameter, with moderately thick walls, and numerous blunt septal spines with a slight upward inclination, sporadically developed; with round mural pores, in two or three alternating rows on each face; and with numerous tabulae, 3 or 4 in 3 mm.

**Remarks.** Three specimens, one pyriform (pl. 2, fig. 7), have matrix and preservation similar to that of *F. ?bryani* from Point Hibbs, although their labels gave no locality except Tasmania. They are considerably altered, but agree fairly well with the Devonian *F. goldfussi*, although there are points of resemblance also to the Silurian *F. gothlandicus*. Lecompte (1939, p. 83) has recently given details of European members of *F. goldfussi*, and Hill and Jones (1940, p. 191) of some Australian members.

**Favosites marginatus** sp. nov. (Pl. 2, figs. 8a, b)

**Material.** Two specimens (F 5486 C6, and F 5486 C3, Australian Museum) from the Chudleigh Limestone, Liena, Mersey R., of which the former is the holotype. Upper Ordovician or Silurian.

**Diagnosis.** Pyriform *Favosites* with corallites 0.5 to 3 mm. in diameter and moderately thick walls crenulate in transverse section, with short horizontal septal spines, and with rather rare pores at the margins of the septal faces.

**Description.** The corallum is pyriform, the larger fragment being 7 cm. tall and 4 cm. wide. The corallites vary in diameter from 0.05 mm. to over 3 mm., the smaller corallites occurring at the angles of the larger. The walls of each corallite are separated from neighbours by a median dark line, and the common wall is about 0.25 mm. thick. In transverse section the walls are usually crenulate, but not in vertical section; numerous short, sharp, horizontal spines are present, a vertical series arising from each projecting crenulation; it is possible that each series has a narrow lamellar base. Mural pores appear to be confined to the margins of the faces near but not through the angles; they are slightly oval, and are about 0.25 mm. wide, and two, but not three, corallites intercommunicate by each. The tabulae are horizontal or slightly domed or sagging, and are rather distant, about 10 in 10 mm.

**Remarks.** The crenulation of the walls and the position of the pores distinguishes this from all other species. The spines are not unlike those of *Columnaria? halli* Nicholson of Lambe (1901, pl. vi, fig. 2a) from the Upper Ordovician of Canada; and Nicholson (1879, p. 201) considered that mural pores might be present in his species.

**MADREPORARIA HELIOLITIDA** Jones and Hill, 1940**Genus Plasmoporella** Kiaer

*Plasmoporella* Kiaer, 1899, p. 34.

*Camptolithus* Lindstrom, 1899, p. 99, genotype, *Lyellia papillata* Rominger, 1876, Silurian, Niagaran: Point Detour, Lake Huron, Michigan, U.S.A.

**Genotype.** *P. convexotabulata forma typica* Kiaer, 1899, p. 35, pl. v, figs. 9-11. Silurian (?Ordovician), Étape 5 of Kiaer, Gasteropodkalk: Stavnaestangen and other localities, Norway.

**Diagnosis.** Heliolitida in which the reticulum consists of globose testae; with domed tabulae, complete or incomplete; and with discrete trabeculae throughout the tissue.

*Remarks.* The genus differs from *Propora* only in the tabulae, which are domed and complete or incomplete, in contrast to the complete, horizontal or sagging plates in *Propora*. It occurs in Étage 5 in Norway (Upper Ordovician or Lower Silurian), in the Lower Silurian of China (Yoh, 1932, p. 69), and in the Niagaran of U.S.A. (Lindstrom, 1899, p. 101).

*Plasmoporella* cf. *convexotabulata* Kiaer. (Pl. 2, fig. 9)

*Material.* One thin section cut from F 5486 C3 (Australian Museum), from the Chudleigh Limestone, Liena, Mersey R., Tasmania. Upper Ordovician or Silurian.

*Diagnosis.* *Plasmoporella* with moderately long septa, loose tissue and complete, distant, domed tabulae.

*Remarks.* The one thin section is almost identical with the typical variety of the genotype from the Upper Ordovician or Lower Silurian of Norway.

*Plasmoporella* sp. (Pl. 2, figs. 10a, b)

*Material.* One fragment from the limestone at the head of the Nelson R., Tasmania, collected by W. R. Browne. Upper Ordovician or Silurian.

*Diagnosis.* *Plasmoporella* in which the domed tabular floors are formed by numerous very small, close tabellae.

*Description.* The tabularia are about 1 mm. in diameter, and are distant about 1 mm. or less. The twelve septa in each tabularium are rather thick, extending from one-third to one-half of the way to the axis of each tabularium, and projecting into the reticulum for an equal distance. There are numerous discrete trabeculae based on the testae, and some on the tabellae. The tabular floors are domed, and the tabellae are very numerous, small and close. The testae are also numerous and small, and are highly globose.

*Remarks.* The fragment differs from the known species in the character of the tabellae, which are smaller, closer, and more globose than in the others, and in the slightly greater length of the septa. It indicates for the limestone containing it an age covered by the range of the genus, which is from the Étage 5 of Norway (Upper Ordovician or Lower Silurian), to the Niagaran (Wenlock) of America.

#### ACKNOWLEDGMENTS.

This work has been carried out in the University of Queensland during tenure of a Research Fellowship within the University of Queensland financed by Commonwealth funds through the Council for Scientific and Industrial Research. Specimens have been loaned by the Tasmanian Department of Mines, the Australian Museum, and by Prof. W. R. Browne of the University of Sydney. The photographs are the work of Mr. E. V. Robinson.

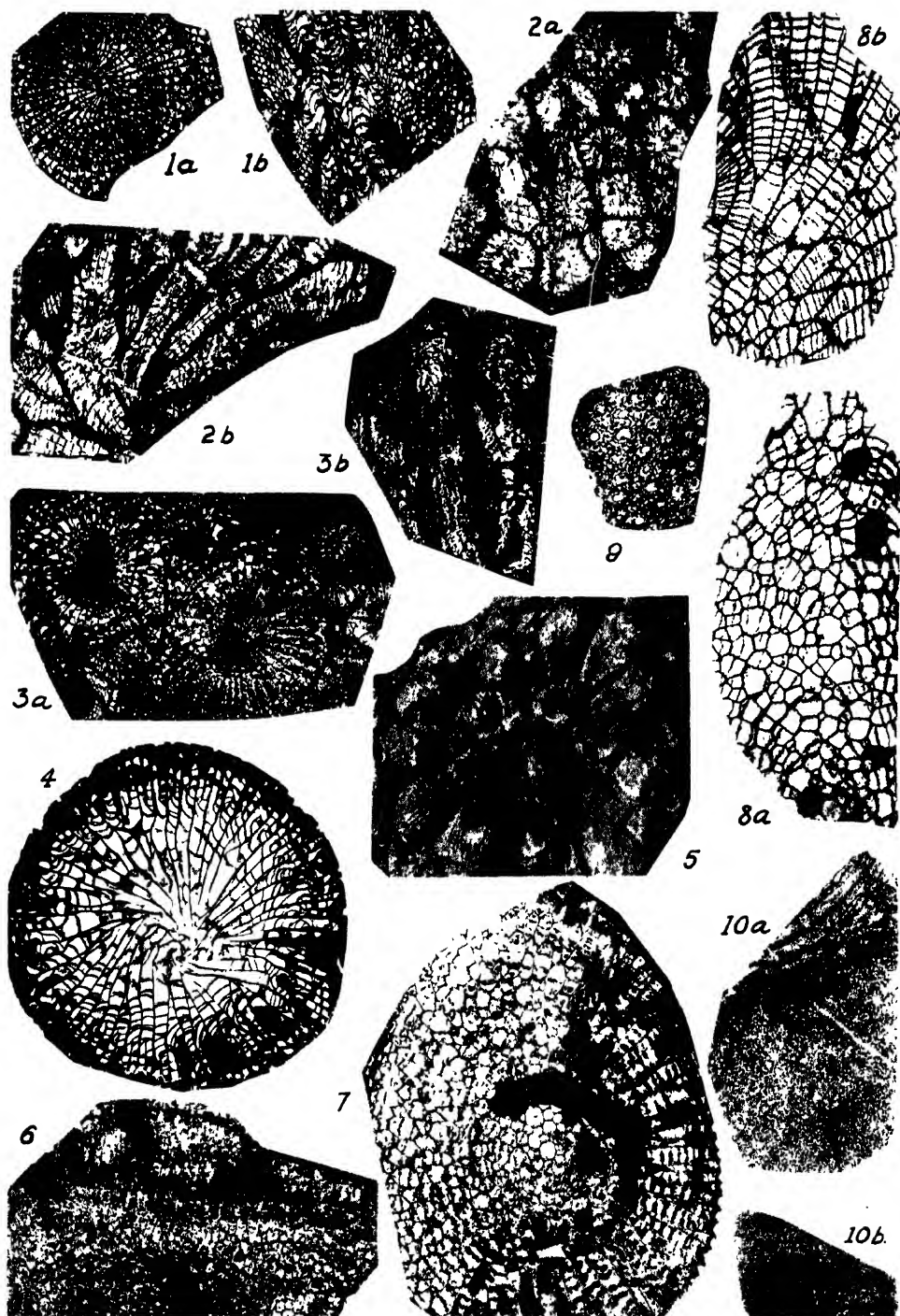
## REFERENCES

- CHAPMAN, F., 1921.—New or little-known Victorian Fossils in the National Museum. Part XXV.—Some Silurian Tabulate Corals. *Proc. Roy. Soc. Viet.* (NS) XXXIII, pp. 212-225, pls. ix-xi.
- EDWARDS, H. M., and HAIME, J., 1851.—Monographie des Polypiers fossiles des Terrains palaeozoiques. *Arch. Mus. Hist. Nat. Paris*, V, pp. 1-502, pls. i-xx.
- ETHERIDGE, R., 1896.—Description of a small Collection of Tasmanian Silurian Fossils presented to the Australian Museum by Mr. A. Montgomery, M.A., Government Geologist, Tasmania. *Rept. Secty. Mines Tasmania*, pp. xli-xlvi, 1 pl.
- , 1904.—A Monograph of the Silurian and Devonian Corals of New South Wales. Part I.—The Genus *Halysites*. *Mem. Geol. Surv. N.S.W., Palaeont.* No. 13, x + 39 pp., 9 pls.
- , 1911.—The Lower Palaeozoic Corals of Chillagoe and Clermont. Part I. *Queensl. Geol. Surv. Publ.* 231, pp. 1-8, pls. A-D.
- FOERSTE, A. F., 1888.—Notes on Palaeozoic Fossils. *Bull. Sci. Labs. Denison Univ.* III, pp. 117-136, pl. 13.
- GOLDFUSS, G. A., 1826-33.—Petrefacta Germaniae. I, pp. 1-76, pls. i-xxv, (1826); pp. 77-164, pls. xxvi-l, (1829); pp. 165-240, pls. li-lxxi, (1831); pp. 241-252, (1833). Düsseldorf.
- HALL, J., 1847.—Natural History of New York, Part VI. Palaeontology of New York. Vol. I, pp. xxiii + 1-338, pls. i-lxxxvii. Albany.
- HILL, D., 1939.—The Devonian Rugose Corals of Lilydale and Loyola, Victoria. *Proc. Roy. Soc. Viet.* (NS) LI, pp. 219-256, pls. xli-xvi.
- , 1940 The Silurian Rugosa of the Yass-Bowning District, N.S.W., *Proc. Linn. Soc. N.S.W.*, LXXV, pp. 388-420, pls. xi-xiii.
- HILL, D., and JONES, O. A., 1940.—The Corals of the Garra Beds, Molong District, New South Wales. *J. Proc. Roy. Soc. N.S.W.*, LXXIV, pp. 175-208, pls. ii-viii.
- JONES, O. A., 1936a.—The Controlling Effect of Environment upon the Corallum in *Favosites*, with a Revision of some Massive Species on this Basis. *Ann. Mag. Nat. Hist.* (10), XVII, pp. 1-24, pls. i-iii.
- , 1936b.—On the Silurian Corals: *Cyathophyllum shearsbyi* and *Helophyllum yassense*. *Mem. Queensl. Mus.* XI, pp. 53-58, pls. v-vii.
- , 1937.—The Australian Massive Species of the Coral Genus *Favosites*. *Rec. Austral. Mus.* XX, pp. 79-102, pls. xi-xvi.
- JONES, O. A., and HILL, D., 1940.—The Heliolitidae of Australia, with a Discussion of the Morphology and Systematic Position of the Family. *Proc. Roy. Soc. Queensl.* LI, pp. 183-215, pls. vi-xi.
- KIAER, J., 1899.—Die Korallenfaunen der Etage 5 des norwegischen Silursystems. *Palaeontograph. Stuttgart*, XLVI, 58 pp., 7 pls.
- LANG, W. D., SMITH, S., and THOMAS, H. D., 1940.—Index of Palaeozoic Coral Genera. vii + 231 pp. British Museum, London.
- LECOMPTE, M., 1939.—Les Tabulés du Dévonien moyen et supérieur du Bord sud du Bassin de Dinant. *Mém. Mus. Roy. Hist. Nat. Belg.* No. 90. 230 pp., 23 pls.
- LINDSTROM, G., 1888.—List of the Fossil Faunas of Sweden. II Upper Silurian. 29 pp. Stockholm.
- , 1899.—Remarks on the Heliolitidae. *Handl. K. Svensk. Vetensk.-Akad.*, XXXII, No. 1, 140 pp., 12 pls.
- NICHOLSON, H. A., 1879.—On the Structure and Affinities of the 'Tabulate Corals' of the Palaeozoic Period. xii + 342 pp., xv pls.
- STUMM, E. C., 1937.—The Lower Middle Devonian Tetracorals of the Nevada Limestone. *J. Palaeont.* XI, pp. 423-443, pls. 53-55.
- SUSSMILCH, C. A., 1914.—An Introduction to the Geology of New South Wales, pp. xviii + 1-269. Sydney.
- WEDEKIND, R., 1923.—Die Gleiderung des Mitteldevons auf Grund von Korallen. *Sitz.-ber. Ges. Berford. ges. Naturw. Marburg.* (1922), pp. 24-35.
- , 1924.—Das Mitteldevon der Eifel. I teil. Die Tetrakorallen des unteren Mitteldevon, *Schrift. Ges. Berford. ges. Naturw. Marburg*, XIV, (3), pp. vii + 1-91.
- , 1927.—Die Zoantharia Rugosa von Gotland (bes. Nordgotland). *Sver. Geol. Undersök.*, Ca, XIX, pp. 1-94 (+1), pls. i-xxx.
- WEISSERMEL, W., 1939.—Neue Beiträge zur Kenntnis der Geologie, Palaeontologie und Petrographie der Umgegend von Konstantinopel. 3. Obersilurische und devonische Korallen, Stromatoporen und Trepostome von der Prinzeninsel Antirovitha und aus Bithynien. *Abh. Preuss. Geol. Landes.* (NF) Heft 190. 131 pp., 15 pls.
- YOH, S. S., 1932.—A beautiful Plasmoporeid Coral from the Fengchu shale of Lower Silurian in S.W. Chekiang. *Bull. Geol. Soc. China*, XII, pp. 69-71, 1 pl.

## PLATE II

All figures x2 diameters approximately, unless otherwise indicated.

- FIG. 1.—*Entelophyllum* sp. F 4195, Australian Museum, from a grey crinoidal limestone on the Gordon R., Silurian. *a*, transverse and *b*, vertical section.
- FIG. 2.—*Favistella cerioides* sp. nov. Holotype, F 5487, Australian Museum, T. Stephens Coll., Chudleigh Limestone, Liena, Mersey R., Upper Ordovician or Silurian. *a*, transverse and *b*, vertical section.
- FIG. 3.—*Heliophyllum ?chillagoense* (Etheridge) Tasmanian Geological Survey Coll., Point Hibbs, ?Devonian. *a*, transverse and *b*, vertical section.
- FIG. 4.—*Hercophyllum shearsbyi* (Sussmilch). F 4211, Australian Museum, limestone on the Gordon R., Wenlock or Ludlow. Transverse section
- FIG. 5.—*Pleurodictyum megastomum* M'Coy. 711, Tasmanian Geological Survey Coll., Tasmania. Internal mould, x1.5 diameters.
- FIG. 6.—*Favosites ?bryani* Jones. Tasmanian Geological Survey Coll. Point Hibbs, ?Devonian. Section.
- FIG. 7.—*Favosites ?goldfussi* d'Orbigny. Tasmanian Geological Survey Collection, Tasmania. ?Devonian. Section. x1.6 diameters.
- FIG. 8.—*Favosites marginatus* sp. nov. Holotype. F 5486 C6, Australian Museum, T. Stephens Coll., Chudleigh Limestone, Liena, Mersey R., Upper Ordovician or Silurian. *a*, transverse, *b*, vertical section.
- FIG. 9.—*Plasmoporella* cf. *convexotabulata* Kiaer Thin section from F 5486 C3, Australian Museum, T. Stephens Coll., Chudleigh Limestone, Liena, Mersey R., Upper Ordovician or Silurian.
- FIG. 10.—*Plasmoporella* sp. W. R. Browne Coll., limestone at the head of the Nelson R., Upper Ordovician or Silurian. *a*, transverse and *b*, vertical section.





## The Grapsid and Ocypodid Crabs of Tasmania

By

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*Raffles Museum, Singapore*

(Read 13th October, 1941)

During a visit to Tasmania lasting from December, 1940, to April, 1941, I made a small collection of shore crabs, chiefly from the neighbourhood of Hobart, which included all but two of the species recorded from the island of the families indicated in the title <sup>(1)</sup>.

Access to the collections and library at the Australian Museum, Sydney, and working facilities very kindly granted by the Director, Dr. A. B. Walkom, have enabled me to prepare this paper. My thanks are also due to Dr. J. Pearson for the loan of collecting materials and for permission to use the Royal Society's library at Hobart.

No new or rare species are recorded, and the paper is intended rather to assist identification of the Tasmanian species of these families of crabs than as a contribution to systematic carcinology. Those unfamiliar with the morphological terms used will find a clear and complete account of them in Hale, 1927 a.

The drawings are traced from photographs, and in some the carapace is slightly foreshortened; no attempt has been made to reproduce the colours or markings.

### Family GRAPSIDAE

Typically the crabs of this family have the carapace flattened and more or less quadrate. The front is broad, and the orbits are at or near the antero-lateral angles, the eye-stalks being short and thick. There is always a distinct gap between the external maxillipeds.

Most of the Grapsids inhabit the seashore and the margins and flats of tidal rivers, some species running actively over the rocks, others living in burrows or under stones and driftwood. Some are more or less predatory, but they exist chiefly by scavenging.

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<sup>(1)</sup> The Soldier Crab, *Mictyris platycheles*, is excluded from this account as the genus, formerly classified with the Ocypodidae, is now regarded as constituting a separate family. A very complete account of the species of the genus is given by McNeill (1926).



## KEY TO THE SUBFAMILIES.

1. The first antennae fold beneath the front in the usual manner, and are not then visible from above

2

The first antennae are placed in deep clefts in the front, and are visible in dorsal view

PLAGUSIINAE

2. No oblique hairy ridge on the outer surface of the external maxillipeds

8

An oblique hairy ridge on the outer surface of the external maxillipeds

SESARMINAE

3. The lower margin of the orbit runs down to the corner of the buccal frame; the inner margin of the merus of the chelipeds is expanded distally into a toothed, laminar process

GRAPSINAE

The lower margin of the orbit does not run down to the corner of the buccal frame; the merus of the cheliped is not thus expanded

VARUNINAE

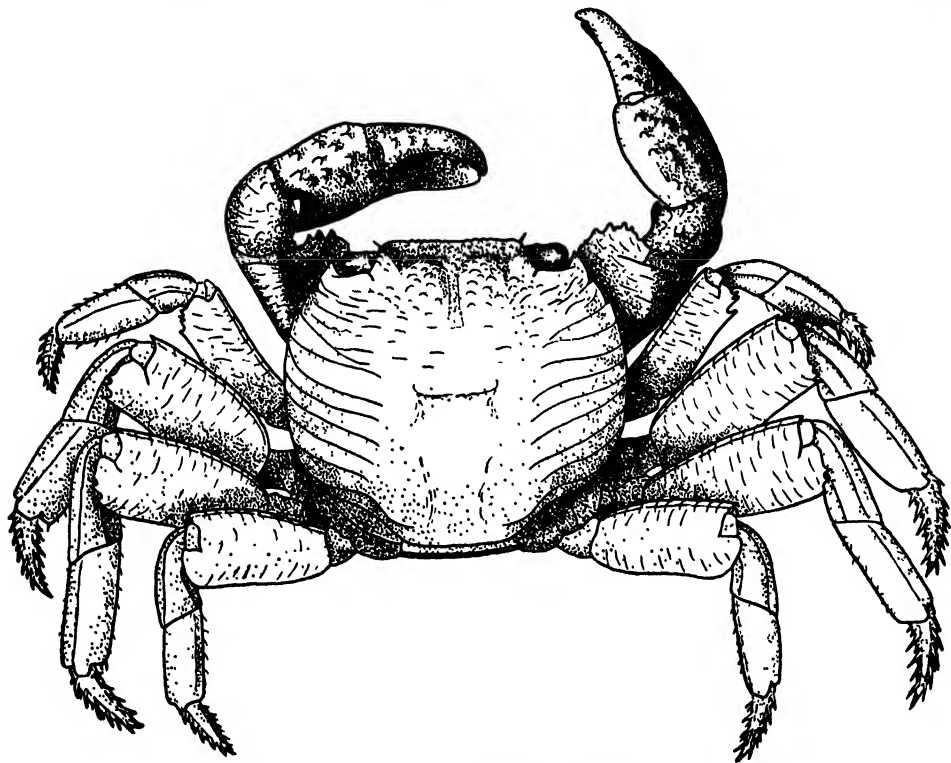


FIG. 1.—*Leptograpsus variegatus*, ♂

## Subfamily GRAPSINAE

Tasmania is situated within the known range of one species.

*Leptograpsus variegatus* (Fabr.). Fig. 1

Hale, 1927, p. 180.

Montgomery, 1931, p. 451.

Balss, 1935, p. 142.

*Material.* I collected none myself, but was able to examine a good series in the collection of the Australian Museum.

*Description.* The carapace is flattened and subquadrate in shape, with the lateral margins curved and carrying two teeth behind the outer orbital angle, the hinder of which may be small and is occasionally absent. The front is broad

and prominent, and its upper surface is coarsely granular. The epigastric region, behind the front, is studded with transverse tubercles. The rest of the carapace is smooth with a number of parallel, obliquely transverse, raised lines on each branchial region. The chelipeds are large in the male; with increasing age and size they become relatively more massive, and the closed fingers gape more and more widely. The inner edge of the arm is expanded to form a toothed laminar process, and there is a tooth at the inner angle of the wrist. The chelae are smooth with some tubercles on the upper part and a ridge on the lower part of the palm, which runs onto the immovable finger; the tubercles are fewer and the ridge fainter in older specimens. The meri of the walking legs are flattened and expanded, and carry an anterior subdistal spine and two or three teeth at the posterior distal margin, except in the last pair, where the teeth are at most faintly indicated. Each dactylus carries four rows of strong spines. Large specimens are as much as 70 mm. in carapace breadth.

*Colour.* Variable, ranging from dark grey to various shades of red and yellow; the claws are blue or purple.

*Distribution.* Southern Australia, ranging north as far as Rockhampton on the east coast, New Zealand, and other South Pacific islands and West Coast of South America. Specimens from Moutouard Island in the Bass Strait are in the Australian Museum collection, and the species most probably occurs in Tasmania.

*Remarks.* This crab is found on exposed, rocky coasts, and runs with great speed and agility over the rocks.

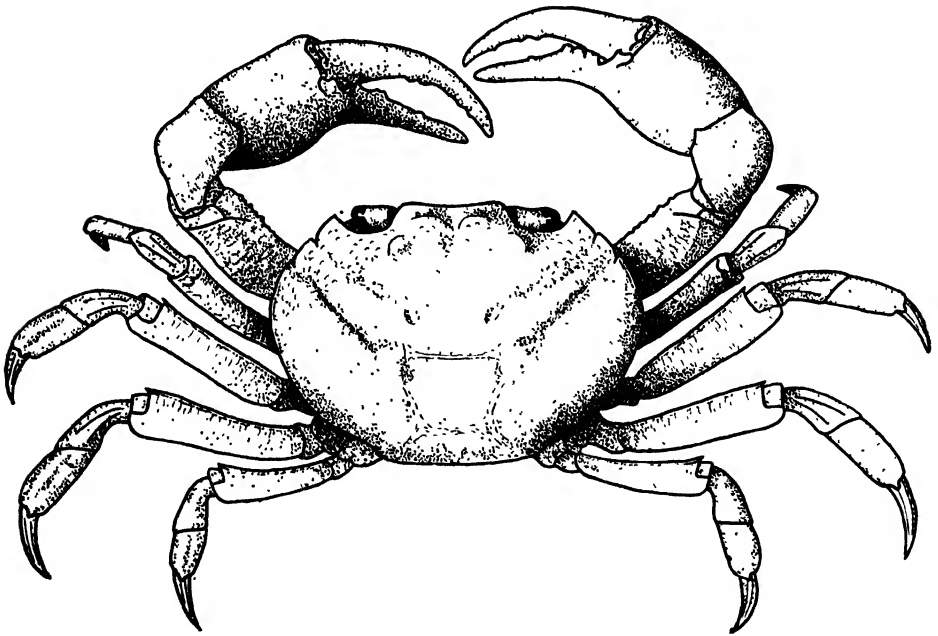


FIG. 2.—*Brachynotus octodentatus*, ♂

## Subfamily VARUNINAE

Two species of one genus are found in Tasmania.

**Brachynotus octodentatus** (Milne Edwards). Fig. 2

Tesch, 1918, p. 106.

Hale, 1927 a, p. 182.

Montgomery, 1931, p. 452 (*Leptograpsodes webhaysi*).

Balss, 1935, p. 142.

**Material.** I collected none myself, but two small specimens from Hawley Beach, Devonport (2.5.38, Coll.A.L.W.), are in the collection of the Hobart Museum.

**Description.** This is a large species, reaching 60 mm. in carapace breadth. The carapace is flattened, but the branchial regions are convex and the post-frontal tubercles distinct. Its anterior and lateral parts are granulate in small, less so in large individuals. The lateral margins are arched, with three teeth behind the outer orbital angles, which decrease in size posteriorly, the last being small and obscure. A deep groove, representing the lateral part of the cervical groove, runs obliquely backwards on each side of the carapace from a point near the second of these teeth. The edge of the front is faintly emarginate. In the female the chelipeds are small and the fingers slender and scarcely gaping when closed. In the male they become larger and increasingly robust with age, the arms (meri) projecting far beyond the edge of the carapace; at the same time the immovable fingers become more strongly bent downwards at an angle from the palm and the dactyli more curved, so that in large males the fingers gape widely when closed. The chelae are smooth, with a few scattered granules on the inner surface in males. The fingers are irregularly dentate along their biting edges, one tooth near the base of the immovable finger being larger than the rest and often itself denticulate.

**Colour.** Olivaceous mottled or spotted with dark brown.

**Distribution.** Tasmania and the southern half of Australia. Haswell's record from the north coast of Tasmania is incorrect (see Hale, 1927 b. p. 313), but the Hobart Museum specimens re-establish it in the fauna of the Island. It occurs also on King Island.

**Remarks.** I agree with Balss that the characters described by Montgomery for *Leptograpsodes webhaysi* are not sufficient to distinguish it from the present species.

*B. octodentatus* occurs on rocky coasts in rock crevices, under stones, etc. The old males are found living singly in burrows.

**Brachynotus spinosus** (Milne Edwards). Fig. 3

Hale, 1927 a, p. 184; 1927 b, p. 312 (*Eriocheir spinosus*).

**Material.** Specimens from the shore at Brown's River, near Hobart, and from the estuary of the Carlton River.

**Description.** A small species, not often exceeding 20 mm. in carapace breadth. The carapace is flattened, and its surface is uneven, the regional boundaries, especially the cervical groove, being well defined. There are three teeth on the lateral margins, behind each outer orbital angle, which usually diminish in size posteriorly, but the second may be the smallest. The greatest breadth of the carapace is at the level of the hindmost of these teeth. Its surface is finely granular anteriorly and smooth elsewhere. A raised line runs back from the posterior lateral tooth to a point over the base of the last leg, cutting off a distinct posterior branchial facet. The front is broad and emarginate in the middle. The corneae of the eyes are peculiar in being black spotted with white. The

male chelipeds are not much enlarged. They are quite smooth, and the fingers scarcely gape when closed. In the basal part of the cleft of the fingers of each chela there is a patch of short, matted hairs. The chelae of the female are more slender and lack this patch of hair. The walking legs are somewhat flattened, and there is an anterior sub-distal spine on the merus of each. In the male there is a tuft of short fur on the distal half of the hinder edge of the propodus of the first and second legs, which is absent in the female or at most faintly indicated on the first leg only. My largest specimen, a female, is 21 mm. in carapace breadth.

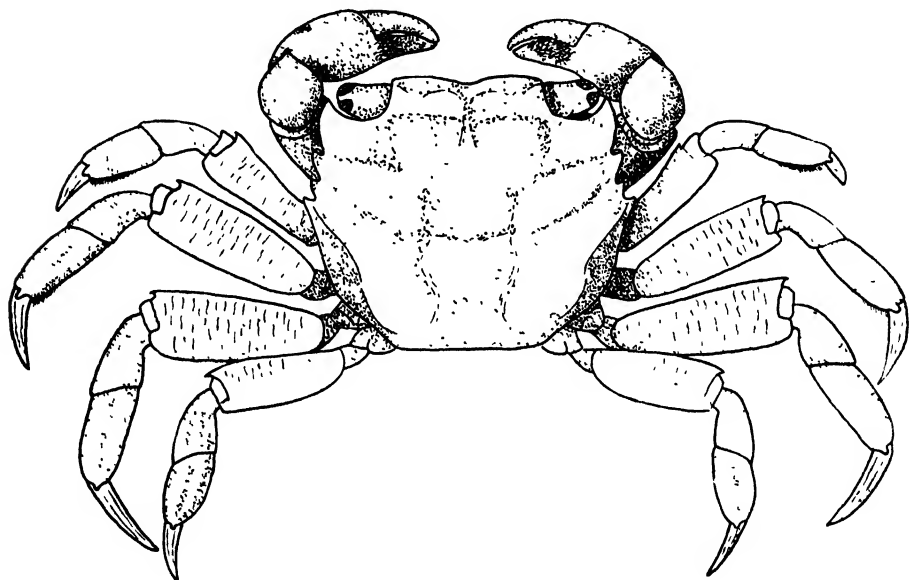


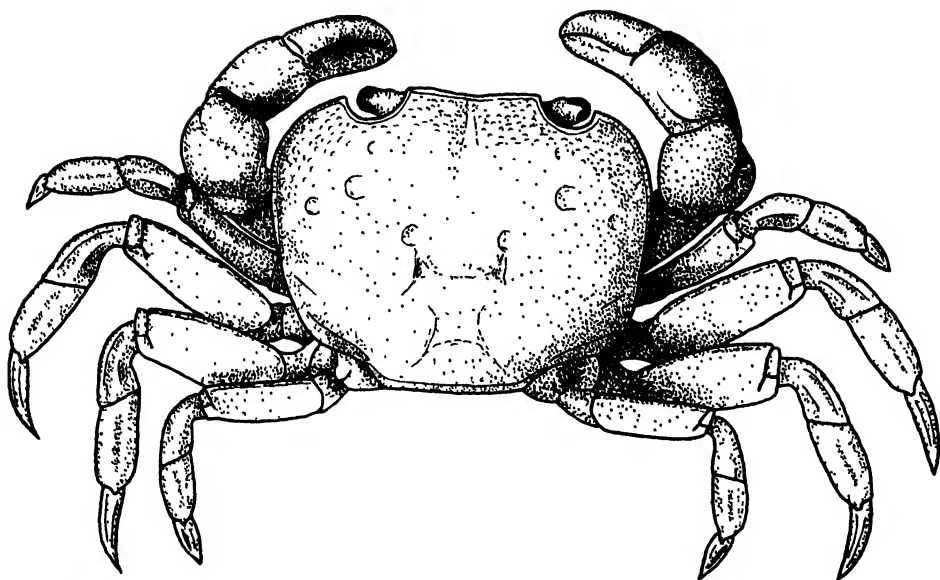
FIG. 3 *Brachynotus spinosus*. ♂

*Colour.* Dull green or brown with or without white markings, which may be so extensive as largely or wholly to replace the darker colour.

*Distribution.* Originally described from Australia, this species appears to be confined there to the southern part of the continent and Tasmania. It would thus seem to be a cold water form, and records in the older literature from the tropical islands of Vanicoro and Upolu are rather hard to explain and, in my opinion, require confirmation.

*Remarks.* Hale placed this species in *Eriocheir*, a genus that includes the well-known Mitten Crab, *E. japonicus*, and is otherwise confined to north China and Japan. The front in *Eriocheir* is typically much narrower than in *B. spinosus*, and the presence of hair on the fingers of the male is characteristic of a number of Varunine genera in addition to *Eriocheir*.

The species was found commonly under stones and driftwood, especially the latter, on the sandy and muddy shores of the Carlton estuary. At Brown's River specimens were found in rock pools, and most of them were much paler in colour than those from the Carlton. Both in maximum and average size, the females collected were larger than the males.

FIG. 4.—*Cyclograpsus audouinii*, ♂

## Subfamily SESARMINAE

Four Tasmanian species included in three genera.

KEY TO THE GENERA (after HALE, 1927 a, p. 175).

- |                                                                                                                        |               |
|------------------------------------------------------------------------------------------------------------------------|---------------|
| 1. Antero-lateral margins cut into teeth                                                                               | 2             |
| Antero-lateral margins not cut into teeth                                                                              | CYCLOGRAPSPUS |
| 2. Body thick and front very declivous. Last abdominal segment of female less than twice as wide as long               | HELICE        |
| Body more depressed with front not markedly declivous. Last abdominal segment of female at least twice as wide as long | PARAGRAPSUS   |

*Cyclograpsus audouinii* (Milne Edwards). Fig. 4

Hale, 1927 a, p. 176.

Balss, 1935, p. 142 (*C. punctatus audouinii*).

**Material.** Specimens from the shore near Brown's River.

**Description.** The carapace is smooth and flat with some symmetrically placed shallow pits, better developed in adults than in juveniles, and with the frontal, orbital, and hepatic regions finely granulate. The gastric, cardiac, and intestinal regions are bounded by ill-defined wrinkled depressions. The frontal, orbital, and lateral borders are raised and finely beaded, the latter quite entire. The front is broad and faintly emarginate in the middle. The chelipeds of the adult male are large, the chelae smooth externally, the inner surface bearing a granular ridge. The largest specimen collected, a male, measured 32 mm. in carapace breadth.

**Colour.** The anterior part of the carapace is dark purple, giving place to pale greenish posteriorly through an intermediate zone irregularly blotched with both colours. The purple may prevail almost entirely at the expense of the green, but the shallow pits are generally pale coloured. The wrists and upper margins of the chelae are purple; the rest of the palm and the fingers white.

*Distribution.* The whole of southern Australia, Tasmania, and New Zealand. Although it is most typically a cold water form, it has been recorded from the tropical Pacific and New Guinea.

*Remarks.* I found this crab only on stony beaches, quite devoid of mud and sand, below cliffs and headlands, living underneath the larger stones.

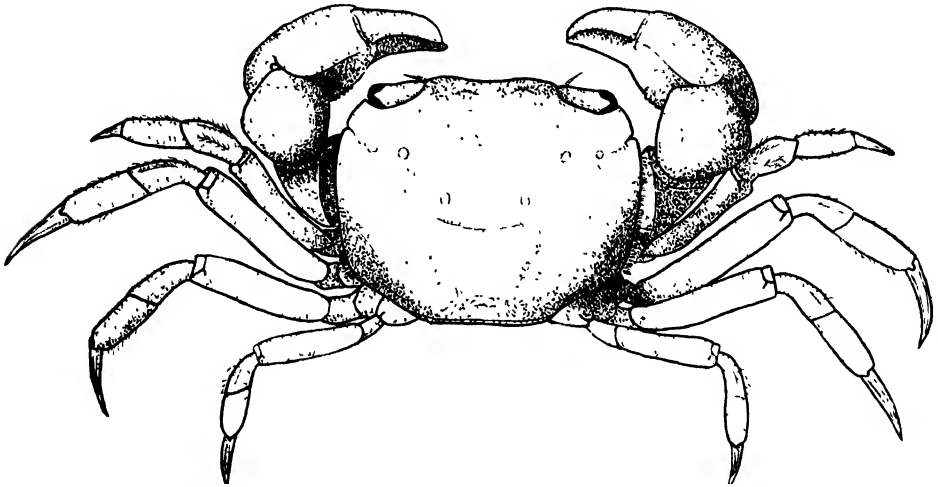


FIG. 5.—*Helice haswellianus*, ♂

*Helice haswellianus* (Whitelegge). Fig. 5

Haswell, 1882, p. 106 (*Chasmagnathus convexus*, nec *C. convexus* de Haan).

Whitelegge, 1890, p. 229 (*Chasmagnathus haswellianus*).

Hale, 1927 a, p. 177.

*Material.* Specimens from Brown's River, near Hobart, burrowing in mud in company with *Heloeius cordiformis*; these were compared with the type of "*C. convexus*" Haswell in the Australian Museum.

*Description.* The carapace is convex in both directions, strongly so fore and aft, the front being so steeply deflexed that its edge is scarcely visible in dorsal view. Its surface is everywhere smooth and polished, the inter-regional grooves shallow and indistinct. The lateral margins are convex with a small incision behind each outer orbital angle. Viewed from the front the frontal margin appears obscurely quadrilobate. The chelae are fairly large and quite smooth externally in the adult male, with a granular swelling on the inner surface and bordered below by a distinct ridge; those of the female are small and finely granular externally. The walking legs are slender, more so than in any of the other Tasmanian Sesarminae.

Adult specimens measure between 25 and 30 mm. in carapace breadth.

*Colour.* The carapace is dark olive or slate colour with some paler, slightly depressed spots and occasionally some lighter markings anteriorly. The legs, wrists and upper margins of the chelae are like the carapace, the outer surface of the chelae yellow.

*Distribution.* South-eastern Australia and Tasmania.

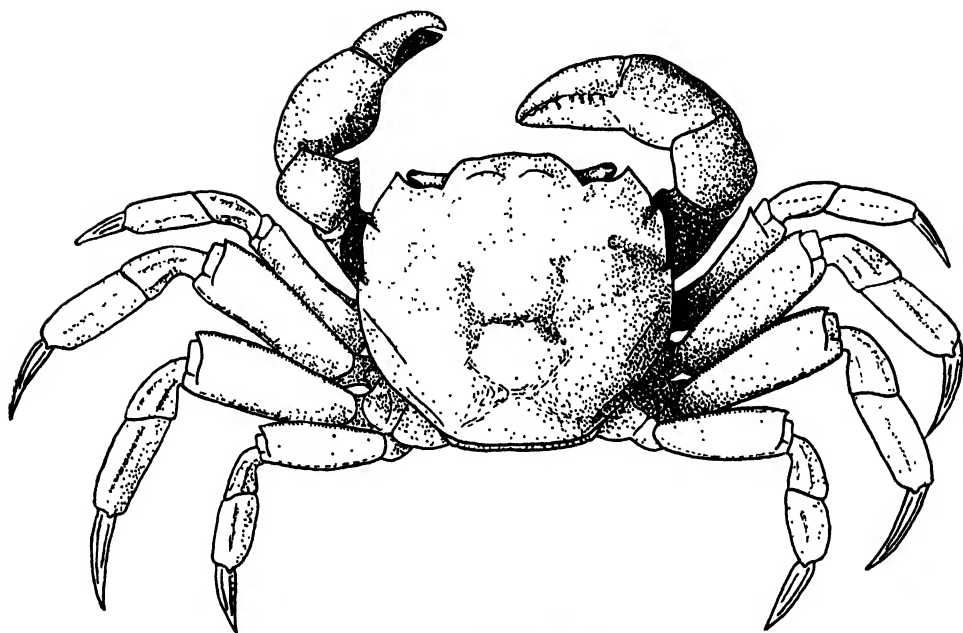


FIG. 6.—*Paragrapsus gaimardii*, ♂

***Paragrapsus gaimardii* (Milne Edwards). Fig. 6**

Haswell, 1882, p. 105.

Tesch, 1918, p. 119 (*Helice gaimardi*).

Hale, 1927 a, p. 179.

*Material.* Specimens from Brown's River and Sandy Bay, Hobart.

*Description.* The carapace is about as broad as long, moderately convex in both directions and everywhere finely granulate. The lateral margins carry two teeth behind the outer orbital angle. There is an oblique granular ridge on each branchial region and another shorter one over the bases of the two last pairs of legs. The front is prominent; its edge is turned up as are those of the lateral margins in front of the posterior teeth. The orbital margins are distinctly angulate where they join the frontal margin near the bases of the eye-stalks. The chelae of the male are fairly large, finely rugose externally, and granular on the inner surface. The biting edges of the fingers do not gape, and are beset with closely and evenly spaced rounded teeth. Those of the female are small with a granular ridge running along the lower part of the outer surface of the palm and onto the immovable finger. The walking legs are broad and flattened. In the adult male the suture between the first and second sternal plates on each side of the abdomen is marked by a prominent ridge.

Adult males measure 40 to 50 mm. in carapace breadth.

*Colour.* The carapace is greenish above, spotted with dark red; posteriorly the spots are distinct, but in front of the cervical groove the red colour becomes finely diffuse or runs together to form blotches. Light coloured depressions are usually present disposed much as in *C. audouinii*. The ground colour of the legs and chelipeds is lighter and the red spots very distinct; outwardly the chelae are yellowish and unmarked.

*Distribution.* Tasmania, Victoria, and South Australia.

*Remarks.* This is the commonest shore crab in the neighbourhood of Hobart. A large stone turned over on any foreshore where the sand contains an admixture of mud often reveals a score or more, which immediately scramble for shelter beneath the overturned stone or even under the feet of the collector; it is found also in sandy and muddy lagoons where there are no stones. This species and *Cyclograpsus audouinii* are never found together. The latter inhabits only the clean, stony beaches, while no surroundings seem to be too dirty for *P. gaimardii*.

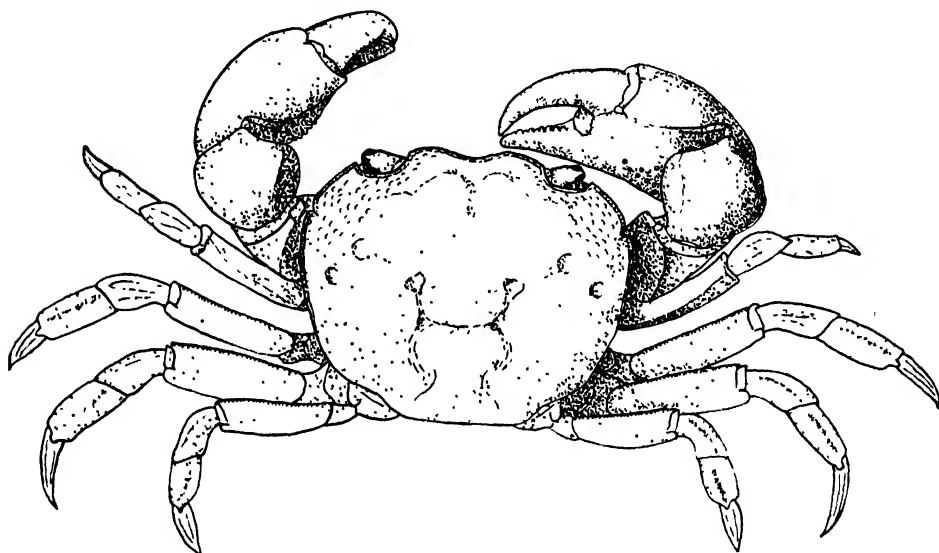


FIG 7 - *Paragrapsus quadridentatus*, ♂

*Paragrapsus quadridentatus* (Milne Edwards). Fig. 7

Haswell, 1882, p. 105.

Tesch, 1918, p. 125.

*Material.* Specimens from Brown's River, near Hobart.

*Description.* The carapace is broader than long, flattened transversely, smooth, and polished except on the frontal, orbital, and hepatic regions, where it is finely granular. A number of shallow pits is disposed on the carapace as in *C. audouinii*, and the gastric, cardiac, and intestinal regions are bordered by wrinkled depressions as in that species, but rather more distinctly. The lateral margins have only one tooth behind the outer orbital angle. The edge of the front is distinctly excavated in the middle. The chelae of the male are very large and swollen, the outer surface smooth, a short row of granules on the inner surface of the palm. The fingers gape when closed and have small, unequal teeth on their biting edges; a large, fleshy protuberance fills the proximal part of the space between the gaping fingers. The female chelae are small and ridged as in *P. gaimardii*. The walking legs are fairly slender, not expanded and flattened as in that species.



*Colour.* The carapace is greenish grey spotted with reddish brown, the spots being much more scattered and less numerous than in *P. gaimardii*. The legs and the upper parts of the chelipeds are the same colour but not spotted, the colour fading to yellowish white on the outside of the chelae.

*Distribution.* Tasmania and Victoria.

*Remarks.* This species has many points of resemblance to *Cyclograpsus audouinii* and is probably more closely related to that species than to *P. gaimardii*. Our present somewhat artificial conception of the two genera refers it to *Paragrapsus* on account of the dentate antero-lateral borders.

In the original description the front was described as almost straight; both Haswell and Tesch (ll.c.) have copied this observation, but it is only true of juvenile specimens; in the adult the front is distinctly excavated in the middle.



FIG. 8.—*Plagusia capensis*, anterior part of carapace.

#### Subfamily PLAGUSIINAE

A single Tasmanian species.

*Plagusia capensis* (de Haan). Fig. 8

Tesch, 1918, p. 129.

Hale, 1927 a, p. 185 (*P. chabrus*).

Balss, 1935, p. 143.

*Material.* Not collected, but the species is well known from Tasmania and the Hobart Museum possesses specimens.

*Description.* The presence of two deep clefts in the front, in which the first antennae are visible, make this crab unmistakable. The carapace is flat and everywhere covered with short hair, and the lateral margins bear three large teeth behind the outer orbital angle. Between the clefts the front is cut into a number of sharp teeth. The chelipeds are covered with rounded tubercles, some of which are disposed in rows. The meri of the walking legs are expanded and spinate along their anterior margins and all the joints are ridged, the intervening grooves being filled with hair. The dactyli carry two rows of spines. Adult males are about 50 mm. in carapace breadth.

*Distribution.* This is best described as circum-subantarctic as the crab occurs on the southern shores of Australia, Africa, and South America and islands included in this zone.

*Remarks.* Like *Leptograpsus* this is an inhabitant of exposed rocky coasts. Its wide range is probably explained by the fact that this and other species of the genus, although normally shore dwellers, are sometimes found on drifting timber in the open sea.

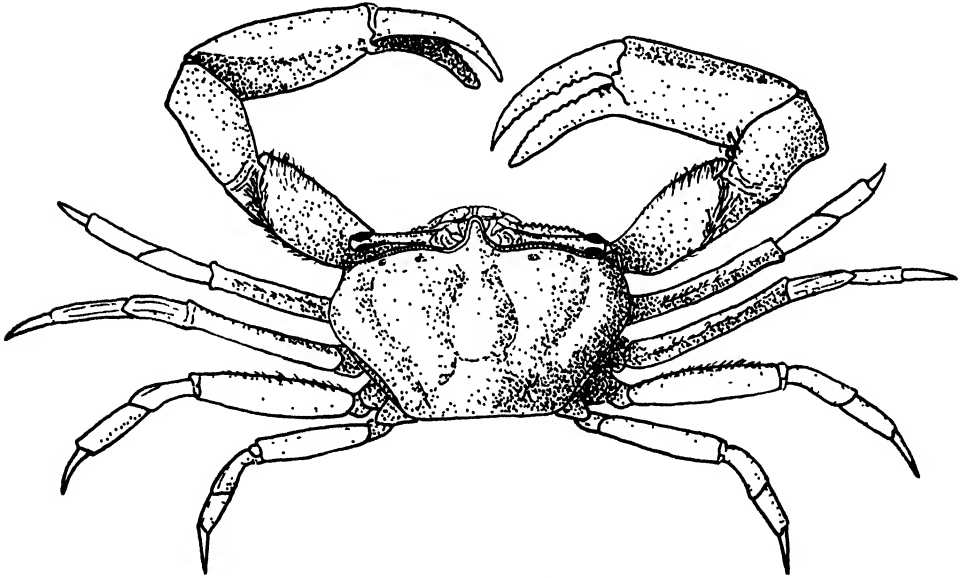


FIG 9.—*Heloecius cordiformis*, ♂

#### Family OCYPODIDAE

This family is distinguished from the *Grapsidae* by the narrow front and correspondingly long orbits and eyestalks, each of which is usually at least a third of the width of the carapace. In addition the external maxillipeds do not leave a wide gap between them when closed.

Like the Grapsids the Ocypodid crabs are shore dwellers and amphibious in habits. Nearly all live in burrows in sand or mud. Most of them feed in a curious and characteristic manner. When the falling tide lays bare a stretch of mud or sand it leaves on the surface a thin film or scum of organic matter. On this the Ocypodids feed, scraping it up with their spoon-shaped fingers. The sand-dwelling forms sieve the sand they put in their mouths, discarding the coarser grains in the form of little pellets, just as do the closely allied Mictyrids.

Only two Ocypodid crabs are known from Tasmania.

*Heloecius cordiformis* (Milne Edwards). Fig. 9

Haswell, 1882, p. 91.

Ward, 1928, p. 242.

*Material.* Specimens from Brown's River, near Hobart, and Orford, on the east coast.

*Description.* The carapace is convex, broad in front and narrow behind, with the regions well marked and the hepatic regions very prominent and inflated so that they almost overhang the small, sharp, forwardly directed outer orbital

angles. The posterior part of each branchial region is separated by a raised line from the rest of the carapace and forms a triangular facet. The front is reduced to a narrow lobe between the bases of the eye-stalks, which are very long. The chelipeds of the adult male are large and greatly elongated, the length of the hand alone being equal to the breadth of the carapace. The immovable finger is bent down at an angle to the palm, which is bordered above and below by a finely milled ridge. The fingers are spoon-shaped at the tips and dentate along their biting edges. The walking legs are smooth, the meri of the first three somewhat hairy at the anterior and posterior margins. Each of the external maxillipeds has a broad, longitudinal groove traversing the ischium and merus.

*Colour.* The carapace, legs, and proximal joints of the chelipeds are dark greenish blue obscurely mottled with brown, the palms of the chelae dull slate blue, paler distally, and fading to dirty white on the fingers <sup>(1)</sup>.

*Distribution.* Tasmania, New Zealand, Victoria, and the east coast of Australia; the most northern locality from which the Australian Museum possesses specimens is Brisbane.

*Remarks.* In Tasmania these crabs inhabit burrows in mud between tide marks near the mouths of rivers; further north they live in mangrove swamps. From their habit of brandishing their chelipeds in the air as if signalling to each other, they are often called "Semaphore Crabs". Ward (l.c.) gives a good account of their habits.

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<sup>(1)</sup> There is probably some distributional variation in the colour: small specimens collected near Sydney have the chelae bright red which turns to purple in the adult. No Tasmanian examples that I saw were thus coloured.

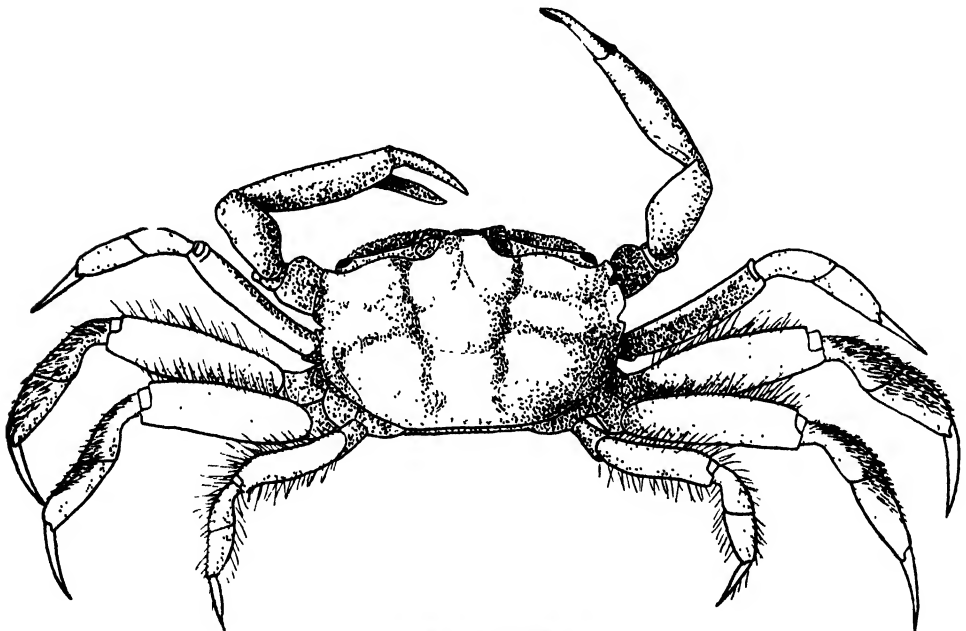


FIG. 10.—*Hemiplax latifrons*, ♂

**Hemiplax latifrons** (Haswell). Fig. 10

Haswell, 1882, p. 90 (*Macrophthalmus latifrons*).

Etheridge and McCulloch, 1916, p. 13.

Hale, 1927 a, p. 186.

*Material.* Specimens from the River Carlton, and from Orford on the east coast, compared with the type in the Australian Museum.

*Description.* The carapace is broad, about half as wide again as it is long, and the inter-regional grooves are well marked. The lateral borders are slightly convex and divided anteriorly by two notches into three teeth (including the outer orbital angle). The second of these is broad and blunt and the third small and angular, and both are turned up so that their edges are considerably above that of the outer orbital angle. The front is between  $\frac{1}{4}$  and  $\frac{1}{2}$  of the breadth of the carapace, and its upper surface is concave. The upper orbital border is sinuous and finely beaded, and the lower is prominent, being visible in dorsal view, and finely denticulate. The chelipeds of the adult are long and fairly robust, those of females and young males small and slender. The chelae are finely granular over the whole of their surface, and the palm and immovable finger are bordered below by a ridge which tends to become obsolete in large males, but is very prominent in females. The immovable finger curves down from the palm, and both fingers are denticulate on the biting edges except at the base of the dactylus. The walking legs are fairly long and very hairy, the hair being especially thick on the carpi and propodi of the second and third legs. The largest male is 27 mm. in carapace breadth.

*Colour.* Dark greenish or greyish brown; the chelae paler. I have seen no specimens approaching "creamy yellow" as described by Hale (l.c.), p. 187.

*Distribution.* Tasmania and south-eastern Australia.

*Remarks.* The characters of this species are misrepresented in Tesch's key to the genus *Macrophthalmus* (1915, p. 154, 155). It is placed in category 17 ("greatest breadth of carapace between the outer orbital angles"), whereas in reality the greatest breadth is at the level of the hindmost lateral teeth, and the species should be in category 20.

These crabs live in burrows in soft mud. They are found at low tide in the same localities as *Heloeccius*, but always nearer the water's edge. They also extend further up the rivers than *Heloeccius*, and are therefore probably more tolerant of fresh water.

## REFERENCES

- BALSS, H., 1935.—Brachyura of the Hamburg Museum Expedition to South-western Australia, 1905. *Journ. Roy. Soc. W. Australia*, xxi, p. 113.
- ETHERIDGE, R., and MCCULLOCH, A. R., 1916.—Sub-fossil Crustaceans from the Coasts of Australia. *Records Australian Mus.*, xi, p. 1.
- HALE, H. M., 1927a.—The Crustaceans of South Australia. Adelaide, 1927
- , 1927b.—The fauna of Kangaroo Island, South Australia, No. 1, the Crustacea. *Trans. Roy. Soc. S. Australia*, LI, p. 307.
- HASWELL, W. A., 1882.—Catalogue of the Australian stalk- and sessile-eyed Crustacea. Sydney, 1882.
- MCCNEILL, F. A., 1926.—Studies in Australian carcinology, No. 2. A revision of the family Mictyridae. *Records Australian Mus.*, xv, p. 100.
- MONTGOMERY, S. K., 1931.—Crustacea Brachyura from the Abrolhos Islands. *Journ. Linn. Soc. London, Zoology*, xxxvii, p. 405.
- TESCH, J. J., 1915.—The Catometopous genus *Macrophthalmus* as represented in the collection of the Leiden Museum. *Zool. Meded. Rijks Mus. Nat. Hist.*, Leiden, 1, p. 149.
- , 1918.—The Decapoda Brachyura of the Siboga Expedition. *Siboga Expedition Monog.* 39c.
- WARD, M., 1928.—The habits of our common shore crabs. *Australian Museum Magazine*, iii, p. 242.
- WHITELEDGE, T., 1889.—List of the marine and freshwater invertebrate fauna of Port Jackson and the neighbourhood. *Journ. Roy. Soc. N.S. Wales*, xxiii, p. 163.



# New Leaf-Hoppers from Tasmania and Queensland

By

J. W. EVANS

(Read 13th October, 1941)

## PLATE III

### EUPTERYGIDAE

*Empoasca maculata* sp. nov.

(Plate 3, fig. 11)

*Length* 3 mm. General coloration bright yellow. *Head*, ventral surface white, but for the fronto-clypeus antero-laterally, which is green; eyes, black. Crown yellow, with or without white markings; ocelli marginal, large. *Pronotum* yellow with irregular white markings, usually four in number, lying against the anterior border. *Scutellum* yellow with white markings. *Tegmen* yellow, hyaline with a distinct brown spot in the distal portion of the cell that lies between the claval suture and Cu. *Male Genitalia* as in Pl. 3, fig. 11. *Type* ♂ from Jandowae, Queensland, on cotton (D. Atherton, 4/4/41), in the Queensland Museum collection (Ho. 15228).

NOTE.—*E. maculata* resembles *E. terrae-reginae* Paoli in the shape and colour-pattern of the head and pronotum. It differs in colour, being yellow and not green, and may be readily identified by the presence of the brown spot on the tegmen.

### *Eutambourina* gen. nov.

The ventral surface of the head, which is triangular in shape, is irregularly pitted. The pits, which resemble those that occur in the Fulgoroidea, are shallow and have thickened margins. Frontal and coronal, but not epicranial, sutures are developed. The crown, which is wider in the centre than against the eyes, is rounded anteriorly and depressed posteriorly. The pronotum is pitted and wider posteriorly than anteriorly, and the sides of the scutellum are raised. The venation of the tegmen is similar to that of *Erythroneura*, excepting that an anal vein is developed. The pleura and the dorsal surface of the abdominal segments are pitted, and the hind tibiae have three rows of long spines.

*Eutambourina punctata* sp. nov. (Genotype)

(Plate 3, figs. 12-14)

*Length* 3.8 mm. *Head*, ante-clypeus brown, smooth; lora and maxillary plates brown with yellow pits; fronto-clypeus and vertex yellow, but for a brown spot at the apex of each frontal suture, and a pair of broad longitudinal brown stripes

that extend posteriorly almost as far as the hind margin of the crown. *Pronotum* and *Scutellum* pale lemon yellow. *Tegmen* hyaline, pale yellow partially suffused with brown, and with a whitish oval area lying against the costal border. *Thorax*, pleural sclerites brown with yellow pits. *Abdomen* pale yellow. *Male Genitalia* as in Pl. 3, fig. 14. *Type* ♂ from Tambourine Mountains, Queensland (R. E. Turner 5/35), in the British Museum collection.

## IDIOCERIDAE

### *Idiocerus tambourinus* sp. nov.

(Plate 3, figs. 1, 2)

*Length* 4.5 mm. *Head*, ventral surface, ante-clypeus, lora and maxillary plates yellow; fronto-clypeus yellow, but for a rose-pink median area close to the hind border; vertex and eyes rose-pink; ocelli yellow, and two yellow muscle impressions between the ocelli and the hind margin of the head. Crown of even width throughout. *Pronotum* with a median pink longitudinal stripe, bordered on each side by yellowish-grey, pink, black, red and yellow zones; these are not distinct stripes but merge into each other. *Scutellum* deep pink, muscle impressions black. *Tegmen* hyaline, greenish-yellow; apex smoky-brown with a broad black band, merging into pink, against the hind border. *Thorax* and *Abdomen*, ventral surface pale yellowish-green. *Male Genitalia* as in Pl. 3, fig. 2. *Type* ♂ from Tambourine Mountains, Queensland (R. E. Turner 6/35), in the British Museum collection.

NOTE.—This is a somewhat variable species, but the general effect of the colour-pattern is as shown in Pl. 3, fig. 1.

### *Idiocerus lacustris* sp. nov.

(Plate 3, fig. 3)

*Length* 5 mm. General coloration yellowish-green. *Head* convex; crown wider in the centre than against the eyes; eyes brown. *Pronotum* shorter than the scutellum. *Tegmen* hyaline-green, apically brown; venation indistinct. *Thorax*, ventral surface pale green. Hind tibia with four spurs set on prominent bases. *Abdomen*, ventral surface pale green. *Male Genitalia* as in Pl. 3, fig. 3. *Type* ♂ from near Lake St. Clair, Tasmania (J. W. E. 2/41), in the Australian Museum collection.

## CICADELLIDAE

### *Cicadella turneri* sp. nov.

(Plate 3, fig. 4)

*Length* 8 mm. *Head*, ventral surface bright yellow, the ante-clypeus tinged with brown; fronto-clypeus bordered with black posteriorly; eyes black, crown yellow with black markings. *Tegmen* greenish-black, apically dark smoky-brown. A narrow yellow hyaline band extends the full length of the costal margin, but is separated from the actual border by a narrow black band. *Thorax* and *Abdomen*, ventral surface yellow. *Type* ♀ from Tambourine Mountains, Queensland (R. E. Turner 4/35), in the British Museum collection.

## MACROPSIDAE

*Macropsis wellingtonensis* sp. nov.

(Plate 3, fig. 6)

*Length* 4 mm. *Head*, ventral surface whitish-yellow with sparse brown punctures, muscle impressions ochreous, eyes dark-brown. Crown wider in the centre than against the eyes. *Pronotum* declivous, sordid whitish-yellow with brown punctures. *Scutellum* yellowish-brown laterally and with a median longitudinal white stripe that widens apically. *Tegmen* colourless-hyaline with four ill-defined blackish-brown transverse areas; veins black and brown with white bars. *Thorax*, ventral surface yellow with dark-brown markings. Hind tibia yellowish-white, the bases of the spines dark-brown. *Abdomen*, ventral surface yellow with dark-brown markings. *Type* ♂ from Mt. Wellington, Tasmania (4000 ft.) (J. W. E. 12/40), in the Australian Museum collection.

*Macropsis fergusonii* sp. nov.

(Plate 3, fig. 6)

*Length* 5 mm. *Head*, ventral surface diamond-shaped, pale brownish-yellow with dark-brown punctures; eyes red. Crown visible from above only as a narrow margin against the eyes on each side. *Pronotum* steeply declivous anteriorly, brown punctures. *Scutellum* yellowish-brown laterally and with a median remainder whitish with sparse dark-brown punctures. *Tegmen* whitish-hyaline evenly mottled with black; veins yellow. *Thorax*, ventral surface black, the pleural sclerites edged with yellow. *Abdomen*, ventral surface yellow. *Type* ♀ from Ferguson's Camp, Lake St. Clair, Tasmania (J. W. E. 2/41), in the Australian Museum collection.

## ULOPIDAE

*Taslopa* gen. nov.

The head is produced and acute apically, and resembles that of *Ulopa* Fall, rather than the head of *Austrolopa* Ev., in that the ante-clypeus is pear-shaped and the fronto-clypeus does not overhang the ante-clypeus. The head and the ventral surface of the thorax are ornamented with white shining dots that resemble grains of sugar.

*Taslopa montana* sp. nov. (Genotype)

(Plate 3, figs. 9, 10)

*Length* 4 mm. *Head*, ventral surface marked with a pattern of light and dark-brown, antennal depressions black. Crown raised and rugose medially; ocelli slightly closer to the fore than to the hind border. *Pronotum* steeply declivous, brown. *Scutellum* dark-brown with yellow markings. *Tegmen*, clavus opaque and coriaceous, the remainder colourless-hyaline; veins brown. *Thorax*, ventral surface, prothorax brown, meso- and metathorax black. *Abdomen*, ventral surface brown. *Type* ♀ from Mt. Wellington, Tasmania (4000 ft) (J. W. E. 12/40), in the Australian Museum collection.



*Taslopa brachyptera* sp. nov.

(Plate 3, figs. 7, 8)

*Length* 4 mm. *Head*, ventral surface marked with a pattern of light and very dark-brown; close to the hind margin is an oval swollen prominence. Crown flat with a median longitudinal ridge; ocelli small and inconspicuous. *Pronotum* on a plane with the crown, brown. *Scutellum* concolorous with the pronotum and with two yellowish markings. *Tegmen* brachypterous, coriaceous, brown but for a whitish streak that widens posteriorly and terminates anteriorly against the hind margin of the pronotum, and a black oval marking. *Thorax*, ventral surface marked with a pattern of brown and black. *Abdomen*, dorsal surface brown streaked with yellow and with ten brown spots on each segment; ventral surface brown. *Type* ♀ from Mt. Wellington, Tasmania (4000 ft.) (J. W. E. 12/40), in the Australian Museum collection.

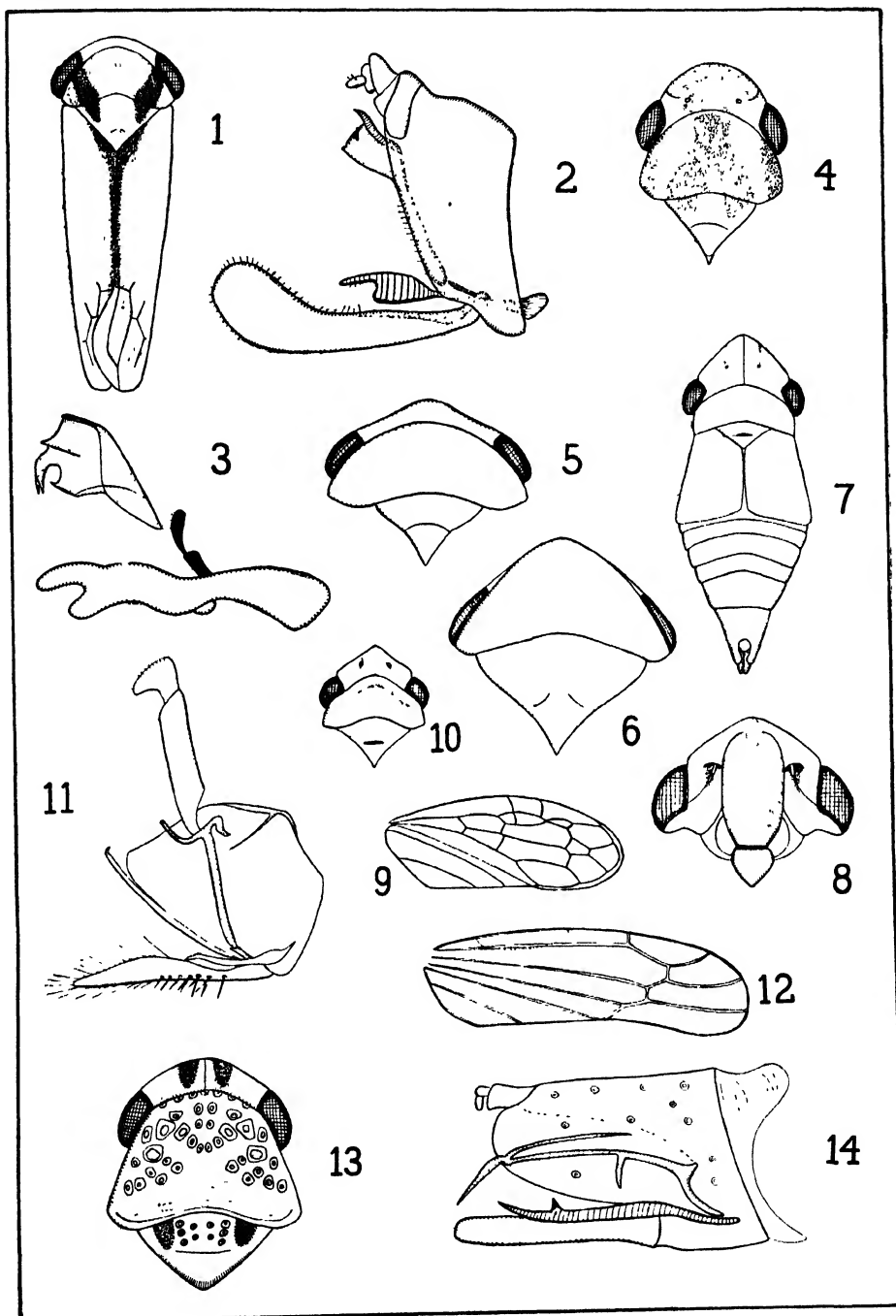
## NOTES

It has been discovered by field observation that a leaf-hopper described as *Austroagalloides rosea* Ev. is the female of one named *A. nigra* Ev. (1936). Accordingly *A. nigra* becomes a synonym of *A. rosea*.

In a collection of Australian leaf-hoppers recently received from the British Museum were three specimens of the Eurymelid, *Bakeriola procurrens* (Jac.), bearing the locality label "Townsville, Queensland, F. P. Dodd, 5/03". This is a most surprising distribution record, as formerly this species was thought to be confined to Western Australia.

## PLATE III

- FIG. 1.—*Idiocerus tambourinus*.
- FIG. 2.—*I. tambourinus*, male genitalia.
- FIG. 3.—*Idiocerus lacustris*, aedeagus and paramere.
- FIG. 4.—*Cicadella turneri*, head and thorax, dorsal aspect.
- FIG. 5.—*Macropsis wellingtonensis*, head and thorax, dorsal aspect.
- FIG. 6.—*Macropsis fergusoni*, head and thorax, dorsal aspect.
- FIG. 7.—*Taslopa brachyptera*.
- FIG. 8.—*T. brachyptera*, tegmen.
- FIG. 9.—*Taslopa montana*, head in ventral aspect.
- FIG. 10.—*T. montana*, head and thorax, dorsal aspect.
- FIG. 11.—*Empoasca maculata*, male genitalia.
- FIG. 12.—*Eutambourina punctata*, tegmen.
- FIG. 13.—*E. punctata*, head and thorax, dorsal aspect.
- FIG. 14.—*E. punctata*, male genitalia.





## A Mecopterous Larva from Tasmania and Notes on the Morphology of the Insect Head

By

J. W. EVANS

(Read 13th October, 1941)

### PLATE IV

In some spirit material which was sorted during the winter of 1941, two larval Mecoptera were discovered. They had been collected in moss on Mt. Wellington during the previous January, at an elevation of between two and three thousand feet.

Four species of Mecoptera are known to occur on Mt. Wellington. These are *Harpobittacus australis* Klug. (Bittacidae); *Apteropanorpa tasmanica* Carp. (Panorpidae); *Nannochorista dipteroides* Tillyard and *N. maculipennis* Tillyard (Nannochoristidae). The larva of *Harpobittacus* has been described (Currie, 1932), and in no way resembles those found. It is probable that these are the larvae of a *Nannochorista* and not of *A. tasmanica*, because the moss was from an environment frequented by *N. dipteroides*. *A. tasmanica* and *N. maculipennis* have so far only been taken in open country, at an elevation of about four thousand feet.

Tillyard (1917) believed *Nannochorista* larvae to be aquatic, because the adult insects are almost always taken close to water. However, as they can be found in equal abundance both close to stagnant alpine pools and to fast-flowing streams, damp moss might even more be expected to provide their natural environment. The suggestion that the larvae are those of *Nannochorista* is supported by their structure. Adult *Nannochorista* spp. retain more archaic characters than any other representatives of the Eumecoptera; hence their larvae might well be expected to have primitive features. The larvae described in this paper are less specialized than any described Mecopterous larvae, and have, as well, certain unusual primitive features associated with the structure of the head.

Applegarth (1939) has stated that very little is known concerning larval Mecoptera, yet they are of the very greatest interest, because it is accepted that the Mecoptera are directly ancestral to all Holometabolous orders of insects, with the exception of the Coleoptera. Further, as the nymphs of all the Hemimetabola hatch from the egg in a post-oligopod phase, which is a later ontogenetic stage than that retained by the larvae of Holometabolous insects, in a polypod Mecopteron larva may be expected to occur more primitive structural characteristics than in any other pterygote insect.

## DESCRIPTION

The two larvae are five and six millimetres long respectively. They are brown in colour and probably in their second instar.

**The Head**

The head is illustrated in Plate IV, figures 1-3. Figure 1 represents the head in facial aspect. Posteriorly a median oval area, the occiput, is separated from the rest of the head by inwardly-curved lateral sutures. Anterior to the occipital sutures are a pair of lateral folds, the postfrontal folds. The coronal suture is the median suture that extends from the hind margin of the occiput to the apex of the frons. The frons is delimited posteriorly by a V-shaped suture, the epicranial suture; laterally by a pair of more or less parallel frontal sutures and anteriorly by the epistomal suture. The epistomal suture is more pronounced than the other sutures and consists of a thickened sunken fold. The median portion of the frons is separated from the rest by a V-shaped ridge and bears a raised tubercle antero-medially.

Lying on each side of the frons, between it and the eyes, are the genae. These are bounded posteriorly by the postgenal sutures, which extend from the eyes on each side as far as the junction of the epicranial and the frontal sutures. The sub-ocular sutures extend from the margin of the eyes on each side as far as the frontal sutures. The clypeus is rectangular, sclerotized anteriorly, and the labrum is wide. The eyes comprise sixteen ommatidia, which lie close together in a compact group. The antennae have three segments. The first is reduced to a narrow band, the second is bulbous and bears several large sensory pits, arranged more or less in two rows, and the apical segment is spine-like. The anterior tentorial pits lie against the frontal sutures between the sub-ocular and the epistomal sutures.

Figure 2 represents the head in ventral aspect. The post-occiput, which consists of a pair of narrow sclerites separated from the rest of the head by the post-occipital suture, borders the foramen magnum on each side, and the cervical sclerites articulate with the occipital condyles, which lie in the centres of the two sides of the post-occiput. The labium consists only of a longitudinally divided sub-mentum and a pair of palps, and the posterior tentorial pits are invaginated between the sub-mentum and the post-occiput.

**The Thorax**

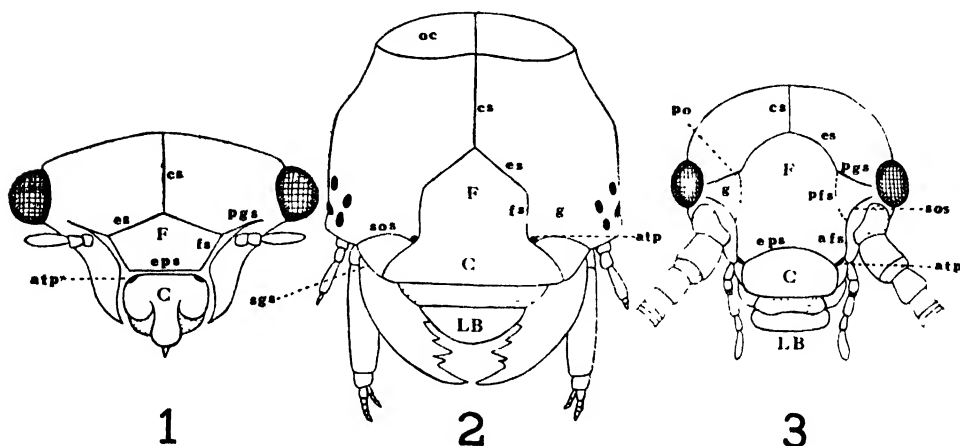
The first and second thoracic segments are illustrated in Plate IV, figures 3 and 5. The metathorax resembles the mesothorax in all essential features. Between the head and the thorax is a distinct neck region, which is supported by a bow-shaped cervical sclerite. Both the meso- and meta-thorax have several raised bosses armed with delicate spines; the position of these is indicated in the figures. The legs have each three segments and their apices are hook-shaped.

**The Abdomen**

An abdominal segment typical of segments 1-7 is illustrated in Plate IV, figures 4 and 6. The terminal segments are illustrated in figure 7. There are ten abdominal segments, the first eight of which bear a pair of appendages and the first nine a pair of spiracles. The appendages, which are simple processes, are slightly curved in a forward direction. In addition to spines (fig. 8c), each of the abdominal segments 1-9 bears a pair of small dorsal processes (fig. 8a), whilst segment 10 has a somewhat larger median dorsal process (fig. 8b). There is a sensory pit close to the base of each dorsal paired process.

## DISCUSSION

In certain groups of insects, such as the Dermaptera, a triangular area may occur in the frontal region of the head which is bordered by faint lines or ridges, but not true sutures, and in addition a pair of widely divergent sutures extend outwards from the anterior apex of the coronal suture. Snodgrass (1935) is of the opinion that these widely divergent sutures are not homologous with true frontal sutures, and following Crampton (1932) terms them postfrontal sutures. This is because not only do these sutures extend as far as the eyes on each side but they may also lie posterior to the paired ocelli.



1. Head of a nymph of *Hemiodoeus fidelis*
2. Head of a larva of *Archichauliodes dubittatus*.
3. Head of a nymph of *Tasmanoperla* sp.

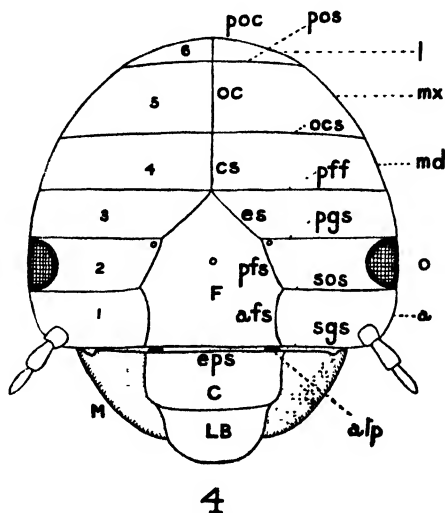
afs., anterior frontal suture; atp., anterior tentorial pit. C., clypeus; cs., coronal suture; es., epicranial suture; eps., epistomal suture; F., frons; fs., frontal suture; g., gena; LB., labrum; oc., occiput; pfs., posterior frontal suture; pgs., postgenal suture; po., position of ocellus; sgs., subgenal suture; sos., subocular suture

In certain insects the frons, instead of being triangular in shape, as is usual, is either five- or seven-sided. Examples of such a frons occur in the nymph of *Hemiodoeus fidelis* Evans (Homoptera, Peloridiidae), the larva of *Archichauliodes dubittatus* Walk. (Neuroptera Corydalidae), the nymph of *Tasmanoperla* sp. (Perlaria, Austroperlidae), and the larva of *Perga* spp. (Hymenoptera, Tenthredinidae). The heads of the three first-named are illustrated in Text-figures 1-3.

The frons of the larva of *Nannochorista* (?) has seven sides, and it is suggested that such a condition is ancestral to a triangular frons.

Following the use of terms already employed in describing the heads of Homoptera (Evans, 1938), the posterior sutures of the frons are referred to as the epicranial sutures and the lateral sutures as the frontal sutures. Each frontal suture consists of an anterior and a posterior frontal suture. The sutures that arise from the anterior apices of the epicranial sutures on each side of the head, and which extend as far as the eyes, have been named, earlier in this paper, the postgenal sutures. It is believed that the postfrontal sutures of Snodgrass and Crampton are the combined epicranial and postgenal sutures. Further, the lateral sutures of a triangular frons are made up of combined epicranial and frontal sutures. In *H. fidelis* epicranial, postgenal, frontal, and epistomal sutures are

present. In *A. dubittatus* epicranial and frontal sutures are developed, but not postgenal and epistomal sutures. In *Tasmanoperla* epicranial, postgenal, anterior frontal, posterior frontal, and epistomal sutures are all present, as they are likewise in *Nannochorista* (?). Paired ocelli, when present, lie in the angles between the postgenal and frontal sutures; their position is indicated in Text-figure 3 (po.).



4. Hypothetical insect head to illustrate the basic segmentation.

a., antennal segment; l., labial segment; m., mandible; md., mandibular segment; mx., maxillary segment; o., ocular segment; ocs., occipital suture; pff., postfrontal fold; pos., post-occipital suture. Other lettering as in previous figures.

Thus the head is seen to have several distinct transverse sutures, of which the three posterior continue across the head and the three anterior are interrupted by the frons. Text-figure 4 is a diagrammatic representation of an insect head based on the head of the larva of *Nannochorista* (?) and on the heads illustrated in Text-figures 1-3. The subocular suture is not homologous with the subocular suture of Snodgrass (fig. 58a), which is the anterior frontal suture, as is also his subantennal suture (fig. 59a). It is possible that the sclerite numbered 1 in Text-figure 4 may be homologous with the sclerite lying anterior to the eyes in *Chauliognathus pennsylvanicus* de Geer (Coleoptera, Cantharidae) figured by Campau (1940), with the anterior lateral sclerites of *A. dubittatus* and with the antennal sclerite of *Tasmanoperla*. Whether this sclerite is also homologous with the pleurostoma of certain Orthoptera is uncertain. In *Corydalus*, Comstock (1920), who termed these sclerites the ante-coxal pieces of the mandibles, believed them to be of clypeal origin. Somite 3, to which no appendage has been assigned, may be identified either with the first postoral somite, as illustrated in Snodgrass (fig. 54a), or with the mandibular somite. If the latter, then somite 4 will be the superlingual segment.

The significance of the median triangular area of the frons is uncertain (Plate IV, fig. 1); it may be associated with the tentorium, as the sides of the triangle lie immediately above the anterior arms of the tentorium. Although

homologous with a similar area to be found in some Dermaptera, it is not homologous with that of Lepidopterous larvae, where it consists of the clypeus. The raised tubercle figured may precede the median ocellus.

The head of the first instar larva of *Panorpa klugi* MacLachlan, figured by Miyake (1912), resembles that of the larva of *Nannochorista* (?) in general features. The frons of the latter is narrower and more elongate, postgenal and occipital sutures are not developed, and the eyes have twenty-eight ommatidia. In addition the labial palps are shorter in relation to the maxillae, and the antennae have more numerous sensory pits.

Crampton has illustrated a head of a *Panorpa* sp. which resembles the head of the Tasmanian insect in the retention of a distinct occipital region, and in the possession of a five-sided frons. It differs in having a pair of transverse sutures that extend widely from the junction of the coronal and epicranial sutures as far as the antennae on each side, and in lacking postgenal sutures. Such an unusual development is difficult to comprehend, unless it is supposed that Crampton's paired transverse and anteriorly directed sutures are actually combined epicranial and postgenal sutures, and his frons identical with the area in Plate IV, fig. 1 which is bordered by dotted lines. This median frontal area is also differentiated in *Apterobittacus apterus* MacLachlan, figured by Applegarth.

With regard to the ventral surface of the head, the labium in *Nannochorista* (?) is better developed than in *A. apterus* and *Harpobittacus tillyardi* E. P., whilst in *Apterobittacus* no trace remains of the distinct divided sub-mentum of *Nannochorista*.

The single thoracic spiracle is in an identical position in *Nannochorista* (?) and *P. klugi*, but in *Apterobittacus* it lies directly below the pronotum, and the arrangement of the thoracic setae of *Nannochorista* (?) is similar to, though not identical with, that of *P. klugi*.

The abdomen of the larvae of *Nannochorista* (?) differs from that of other known Mecopterous larvae in lacking dorsal annulated setae, such as are well developed in every segment of first-instar specimens of *P. klugi*, and retained though reduced, excepting on the eighth and ninth segments, in later instars. The simple nature of the setae of *Nannochorista* (?) can best be explained on the grounds that they are primitive rather than reduced structures.

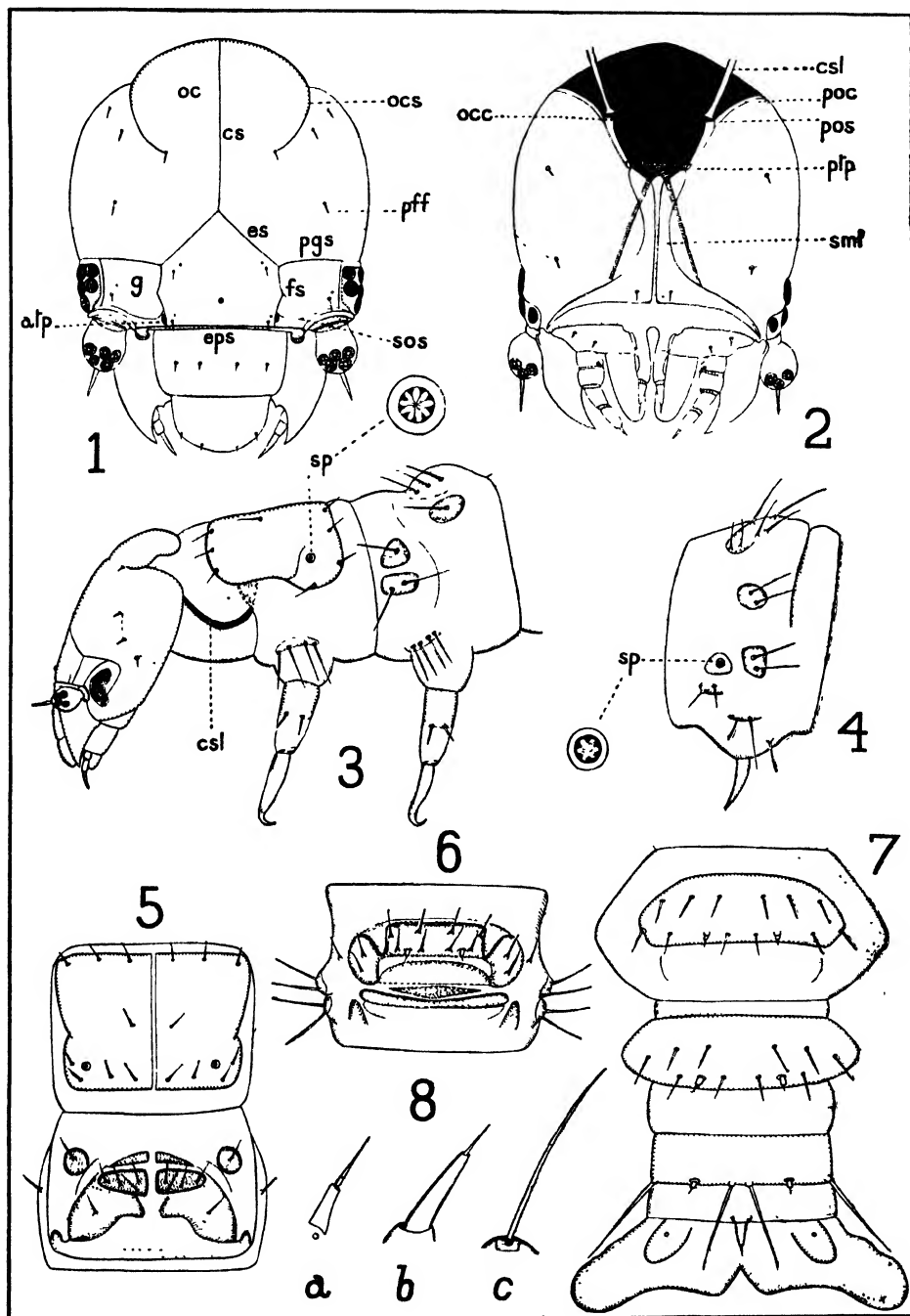
## REFERENCES

- APPLEGARTH, A. G., 1939.—The Larva of *Apterobittacus apterus*. *Microentomology* IV (4), 109.  
 CAMPAU, E. J., 1940.—The Morphology of *Chauliognathus pennsylvanicus*. *Microentomology* V (3), 57.  
 COMSTOCK, J. H., 1920.—An Introduction to Entomology. Comstock Publishing Co., Ithaca, N.Y.  
 CRAMPTON, G. C., 1932.—A Phylogenetic Study of the Head Capsule in certain Orthopteroid, Psocoid, Hemipteroid, and Holometabolous Insects. *Bull. Brooklyn Ent. Soc.* XXVII (1): 19.  
 CURRIE, G. A., 1932.—Some Notes on the Biology and Morphology of the immature stages of *Harpobittacus tillyardi*. *Proc. Linn. Soc. N.S.W.* LVII (3-4); 16.  
 EVANS, J. W., 1938.—The Morphology of the Head of Homoptera. *Pap. R. Soc. Tas.*: 1.  
 MIYAKE, T., 1912.—The Life-History of *Panorpa klugi*. *Jour. Agric. Imp. Univ. Tokyo* IV: 117.  
 SNODGRASS, R. E., 1935.—Principles of Insect Morphology. McGraw-Hill Book Co. Inc., N.Y.  
 TILLYARD, R. J., 1917.—Studies in Australian Mecoptera, No. 1. *Proc. Linn. Soc. N.S.W.* XLII (2): 284.



#### PLATE IV

- FIG. 1.—Head of larva of *Nannochorista* sp. (?) in facial aspect. atp., anterior tentorial pit; cs., coronal suture, eps., epistomal suture; es., epicranial suture; fs., frontal suture; g., gena; oc., occiput, ocs., occipital suture, pff., postfrontal fold; pgs., postgenal suture, sos., subocular suture.
- FIG. 2.—Head of larva of *Nannochorista* sp. (?) in ventral aspect. csl., cervical sclerite; occ., occipital condyle, poc., post-occiput; pos., post-occipital suture; ptp., posterior tentorial pit; smt., sub-mentum
- FIG. 3.—Head and two anterior thoracic segments of the larva of *Nannochorista* sp. (?) in lateral aspect sp., spiracle, csl., cervical sclerite.
- FIG. 4.—Second abdominal segment of the larva of *Nannochorista* sp. (?) in lateral aspect.
- FIG. 5.—Two anterior thoracic segments of the larva of *Nannochorista* sp. (?) in dorsal aspect.
- FIG. 6.—Second abdominal segment of the larva of *Nannochorista* sp. (?) in dorsal aspect.
- FIG. 7.—Apical abdominal segments of the larva of *Nannochorista* sp. (?) in dorsal aspect.
- FIG. 8.—(a) dorsal abdominal process; (b) median terminal dorsal abdominal process, (c) thoracic and abdominal seta





## The Phylogeny of the Homoptera

By

J. W. EVANS

(Read 10th November, 1941)

The question of the phylogeny of the Homoptera does not remain unsettled for want of discussion, as several authors have expressed most definite, though often contradictory, views on the subject. A few years ago a Bulletin entitled 'The Phylogeny of the Hemiptera based on the Study of the Head Capsule' was published in the United States (Spooner, 1938). This work is no mere short paper, but a considerable contribution of over one hundred pages, containing close on four hundred figures. For this reason, quite apart from its obvious worth as a contribution to the comparative morphology of insects, it merits close attention. It consists of two parts; the first part deals with the Homoptera and the second with the Heteroptera, and at the end of each part the conclusions reached by the author with respect to phylogeny are expressed as trees. As far as the Heteroptera are concerned, no comment is offered, but the present paper has been written to dispute certain conclusions reached by Spooner regarding the inter-relationships of the Homoptera, and to present alternative proposals.

In the phylogenetic tree for the Homoptera three main lines of descent are shown radiating from the Protohomopterous stem. Two of these give rise to the Fulgoridae and Peloridiidae respectively and the third to the Cercopidae, all the several other groups of Homoptera, apart from those mentioned above, then being derived direct from the Cercopidae. The separate derivation of the Fulgoridae and Peloridiidae from the Protohomopterous stem is not questioned, in fact an identical suggestion has been made previously (Evans, 1938). The points disputed are the derivation of the Sternorrhyncha from the Cercopidae and the dual origin claimed for the Jassoidea.

Crawford (1914) in his monumental work on the Psyllidae suggested that many characters borne by the group point to a close relationship with the higher Homoptera, especially the Cicadidae, Membracidae, and related families. At the same time he acknowledged that he was not prepared to make a definite pronouncement on relationships. Muir (1930) was of the opinion that the Psyllidae represent a specialization, considerably by reduction, of the Cicadoidea, and Myers (1929) believed that the relative simplicity of the Sternorrhyncha was a secondary specialization. Tillyard (1926), as a result of a study of the wing venation of Lower Permian Homoptera, suggested that the Sternorrhyncha were less primitive than the Auchenorrhyncha. Nevertheless, although there would seem to be fairly general agreement that the Sternorrhyncha, and the Psyllidae in particular, are derived from the Auchenorrhyncha, contrary views have been expressed. Thus Kirkaldy (1906) mentions that Ashmead, in a discussion of Osborn's paper on the phylogeny of the Homoptera (Osborn, 1895), put forward the suggestion that the Auchenorrhyncha were derived from the Sternorrhyncha.

Ideas on relationships based on the study of a single character are notoriously unreliable, but it is believed that, so far as the Homoptera are concerned, the structure of the head-capsule, correctly interpreted, offers a reasonable basis for phylogenetic conclusions.

If a comparison is made between the heads of an aphid, a psyllid, and a nymph of a peloriid, it will at once be seen that they possess a striking characteristic in common. This is the separation of the head into two parts by the epistomal and subgenal sutures. There are other resemblances as well which can best be appreciated by reference to published figures. If first the head of a nymph of the peloriid *Hemiodocus fidelis* (illustrated in Evans, 1938, 1942; Snodgrass, 1938) is compared with the head of the psyllid *Paurocephala magnifrons* (Crawford, Pl. 3, fig. 16), the following points will be noted. Both have a distinct five-sided frons, from the posterior corners of which postgenal sutures arise, and both have a small distinct clypeus which is not separated into two parts by a transverse suture. Spooner gives a figure of the head of the psyllid *Pachypsylla celtidis-mamma* (Pl. 2, fig. 34) in which the clypeus is indicated as possessing two parts. This is because the genal cones have been labelled 'post-clypeus' and the actual complete clypeus 'ante-clypeus'.

The retention of a postgenal suture in the Psyllidae is of considerable interest. It extends from the lateral apices of the frons on each side in the direction of the eyes, and then from close to the eyes continues posteriorly, more or less at right angles to its former direction, as far as the hind margin of the head. On the crown it may either lie against the internal margins of the eyes or be slightly separated from them. The paired ocelli lie close to the apices of these sutures. Apart from in the Psyllidae and in the nymphs of the Peloriidae, postgenal sutures do not occur in any other Homopterous types, although they are present in a few other groups of insects, such as the Dermaptera and Perlaria. In these, where lateral frontal sutures are absent, the true identity of postgenal sutures as such, has not been recognized and they have been referred to as 'postfrontal sutures' (Snodgrass, 1935). Such postfrontal sutures actually comprise combined epicranial and postgenal sutures (Evans, 1942).

If next the head of an aphid, such as *Lachnus* sp. (Spooner, Pl. 2, fig. 33), is compared with the head of *Hemiodocus*, two noteworthy resemblances will be apparent. Both have complete small maxillary plates which are not attached in any way to the genae, and both have a clypeus without a transverse division, but with lateral lobes. These lobes are homologous with the lora of the Auchenorrhyncha.

The following characters of the Homopterous head are believed to be primitive: the complete separation of the clypeus from the frons; the complete separation of the maxillary plates from the genae; the possession of a clypeus lacking a median transverse division; the possession of a clypeus with lateral lobes which are separated from the median part of the clypeus by sutures that do not extend as far as the epistomal suture. The following are believed to be secondary developments: the partial or complete fusion of the frons with the clypeus and the enlargement of the clypeus at the expense of the frons; the fusion of the maxillary plates with the genae; the separation of the clypeus into two parts by a transverse division; the backward extension of the longitudinal clypeal sutures, their junction with the lateral frontal sutures, and the partial or complete obliteration of the epistomal suture.

Snodgrass (1938) has suggested that one of the characters claimed above as primitive is actually a secondary development. According to him, the lateral lobes of the clypeus are of hypopharyngeal origin and their connexion with the

post-clypeus a secondary union. In his opinion the obliteration of the clypeolateral sutures which occurs in the Peloridiidae, Aphididae, and certain Fulgoroidea is a progressive development from the condition which occurs in the majority of the Auchenorrhyncha, where separate loral plates are present. Whilst unable to offer an alternative explanation to account for the union of the lora with the hypopharynx, the hypothesis proposed by Snodgrass is not accepted. This is because of the supporting array of characters in the Peloridiidae, which are undoubtedly of a primitive nature.

In the cercopid head, not only are the maxillary plates fused with the genae, but no trace remains of the subgenal suture; the clypeus is divided into two parts and enormously enlarged posteriorly, and the epistomal suture, in those species where it may still be recognized, is so arched that the anterior tentorial pits lie close to the antennae. No trace of postgenal sutures remains, and, in the adult head, even the coronal suture is not distinct.

Thus it is clear that, on the basis of cephalic structure, whilst it might be justifiable to derive the Aphididae and the Psyllidae from the Protohomopterous stem close to the origin of the Peloridiidae and Fulgoroidea, no adequate reasons can be presented to explain a cercopid origin for the Sternorrhyncha. Carpenter (1932) has proposed the name Palaeorrhyncha for a division of the Homoptera that occurred in Permian times and which, with respect to wing venation, combined the main features of recent groups. It may well be that the Auchenorrhyncha and the Sternorrhyncha have both arisen from the Palaeorrhyncha. This suggestion obviates the necessity of attempting to derive either of the two principal present-day Homopterous divisions from the other.

In regard to the origin of the Jassoidea, Spooner has suggested that the group represented by *Oncometopia* Stål (Cicadellidae) may have been derived from the Cercopinae and all the several other jassoid families from the Aphrophorinae. Whilst not disputing that the suggestion is reasonable if head structure alone is considered, other characters lend it no support. For instance, in the hind-wings of insects in all jassoid families, with the exception of the Aethalionidae, the media has two branches ( $M_1 + 2$  and  $M_2 + 3$ ), although occasionally  $M_3 + 4$  may be fused apically with  $M_1 + 2$ , also the first cubital vein is undivided. In both the Cercopinae and the Aphrophorinae the media terminates as a single vein, whilst  $Cu_1$  has two branches,  $Cu_1$  and  $Cu_{1+2}$ . This common characteristic which the Cicadellidae share with other jassoid families is only one of several that could be chosen to stress the fact that, although the Jassoidea may well have arisen from the Cercopidae, they are a monophyletic group. Our present knowledge is insufficient to make definite pronouncements possible concerning other derivations presented in Spooner's phylogenetic tree. Nevertheless, though the Membracidae may have arisen direct from the Cercopidae as suggested in the tree, there is much to be said in favour of deriving them instead from the Jassoidea.

## REFERENCES

- CARPENTER, F. M., 1932.—The Lower Permian Insects of Kansas, Pt. 5. *American Jour. Sci.* XXIV; 1.  
 CRAWFORD, D. L., 1914.—A Monograph of the Psyllidae of the New World. *U.S. Nat. Mus. Bull.* LXXXV.  
 EVANS, J. W., 1938.—The Morphology of the Head of Homoptera. *Papers Roy. Soc. Tas.* 1937 (1938), p. 1.  
 ———, 1942.—A Mecopterous Larva from Tasmania and Notes on the Morphology of the Insect Head. *Papers Roy. Soc. Tas.* 1941 (1942), p. 31.  
 KIRKALDY, G. W., 1906.—Leaf-Hoppers. *Bull. Hawaii Sug. Ass. Ent.* I (9).

- MUIR, F., 1930.—Notes on certain controversial points of Morphology of the Abdomen and Genitalia of Psyllidae. *Ann. Mag. Nat. Hist.* (10) V; 545.
- MYERS, J. G., 1929.—*Insect Singers*. G. Routledge and Sons, London.
- OSBORN, H., 1895.—The Phylogeny of the Hemiptera. *Proc. Ent. Soc. Washington* III; 185
- SNODGRASS, R. E., 1935.—*Principles of Insect Morphology*. McGraw-Hill Book Co. Inc., N.Y.
- , 1938.—The Loral Plates and Hypopharynx of Hemiptera. *Proc. Ent. Soc. Washington* v. XL, pt. 8; 228.
- SPOONER, C. S., 1938.—The Phylogeny of the Hemiptera based on a study of the Head Capsule. *Univ. Illinois Bull.*, v. XXXV, No. 70.
- TILLYARD, R. J., 1926.—Kansas Permian Insects Pt. 9, *American Journ. Sci.* XI; 38.

## A New Ichthyobdellid Leech and its Egg-capsules

By

V. V. HICKMAN

(Read 10th November, 1941)

### PLATES V, VI

The leech here described was found together with its egg-capsules on a small shell washed-up on the beach at Sandy Bay, Hobart, 28th October, 1940.

There are very few records of marine leeches having been found in association with their egg-capsules, and it seems desirable, therefore, that some account of the present specimens should be published. The leech is a new species belonging to the genus *Pontobdella*. The name *Pontobdella verrucosa* is suggested.

Suborder  
Family  
Genus

Rhynchobdellae  
Ichthyobdellidae  
*Pontobdella*, Leach, 1815

### *Pontobdella verrucosa* n. sp.

*Description.* Approximate total length, in alcohol, 37 mm.; greatest width 3.5 mm. The body is fusiform, circular in section, and narrowed towards the front (Plate VI, fig. 6). The living animal is light-brown in colour with a dark-brown triangular patch on the dorsal side of the anterior sucker. The larger tubercles are tipped with white, and annuli 23 and 29 are almost ringed with white or pale cream. In alcohol, however, these markings disappear and the leech assumes a uniform mustard-yellow hue without any special marks except the triangular brown patch on the sucker.

The anterior sucker is 2.26 mm. in diameter, cup-shaped, attached excentrically, and provided with four pairs of distinct submarginal papillae. The oral surface of the sucker is corrugated to form 12 radial furrows. No eyes are present.

The posterior sucker is cup-shaped, 3.54 mm. in diameter, attached centrally, much wider than the anterior sucker, but only slightly wider than the greatest width of the body.

There are 57 annuli behind the anterior sucker. A complete somite consists of three annuli. The anterior and posterior annuli of the somite are about equal in width and smaller than the middle ring, which is broad and lodges a ganglion of the ventral nerve chain (Plate V, figs. 1 and 2).



The anterior sucker is composed of somites I-V. Somites VI-IX and XIII-XXIV are complete with three annuli; X-XII are biannulate. The clitellum comprises the five narrow rings lying between the broad annuli of somites X and XIII (Plate V, fig. 1). The annulation and metamerism in the anal region are obscure. Somites XXV-XXVII appear to be uniannulate. Annulus 55 is divided below but not above. There is, however, on the dorsal side a small additional tubercle which is unpaired and which may indicate that the annulus is double. Annulus 56 is divided by a transverse groove on the dorsal side, but there is no corresponding division on the ventral surface. Annulus 57 is complete but without tubercles.

The normal arrangement of tubercles on a typical somite is as follows:—

The broad middle annulus is provided with four large tubercles above and four smaller ones below. The anterior and posterior annuli of the somite have six dorsal and six ventral tubercles. Of the six dorsal tubercles the middle pair are the smallest (Plate V, fig. 2). Sometimes there is a small median ventral tubercle on an annulus, and other small tubercles may be interposed between those normally present.

The mouth is a small central aperture in the front sucker.

The male genital pore lies between annuli 16 and 17; the female aperture is between annuli 18 and 19.

The anus lies in the dorsal transverse groove on annulus 56. The division of the annulus by this dorsal groove makes the anus appear to be separated from the posterior sucker by two annuli (Plate V, fig. 3).

#### THE EGG-CAPSULES

As mentioned above the egg-capsules were found attached to a shell stranded on the beach at Sandy Bay. The adult leech was coiled up over the capsules and was still alive (Plate V, fig. 5). The specimens were placed in sea-water and kept in the laboratory from 28th October to 26th November, 1940. By changing the sea-water frequently no difficulty was experienced in keeping both the adult and the embryos alive.

The shell was somewhat worn but appeared to be a right valve of the common *Dosinia coerulea* Reeve. There were 31 capsules in a group on the inner surface of the shell near the hinge line (Plate VI, fig. 7). Each capsule was oval in shape and composed of a transparent brown leather-like material, the surface of which was quite smooth and without any pattern. At each end, however, was a small circular spot. At one end the spot was nearer the upper surface than at the other end and formed a kind of operculum. This was forced open by the young leech when it emerged from the capsule. The capsules were very uniform in size and measured about 2.61 mm. long and 1.63 mm. wide.

During the 30 days the specimens were kept in sea-water in the laboratory, the adult leech usually rested near the capsules. Sometimes, however, it would leave them and move about in the water, later returning to the shell and coiling up in the attitude shown in Plate V, fig. 5.

Each capsule contained only one embryo. Seventeen young leeches completed their development and escaped from the capsules before the 26th November, 1940. They closely resembled the adult.

About ten species are now recognised as belonging to the genus *Pontobdella* (See Scriban and Autrum, 1934, p. (8) 338). These may be divided into two groups, viz., those in which the typical somite is triannulate and those in which it is quadrannulate. *Pontobdella verrucosa* belongs to the former group and is closely allied to *Pontobdella loricata*, Harding (1924, p. 490). The latter species, which is recorded from India, has, however, a clitellum composed of seven rings.

Moreover the figure which Harding gives shows the dorsal tubercles on the smaller annuli of a typical somite to be about equal in size, whereas in *P. verrucosa* the two middle tubercles are much smaller than the others on the dorsal side of the ring.

The type specimen of *Pontobdella verrucosa* and its egg-capsules will be lodged in the Australian Museum, Sydney.

Acknowledgments are made to the Trustees of the John Ralston Bequest, under whose auspices the above work was carried out.

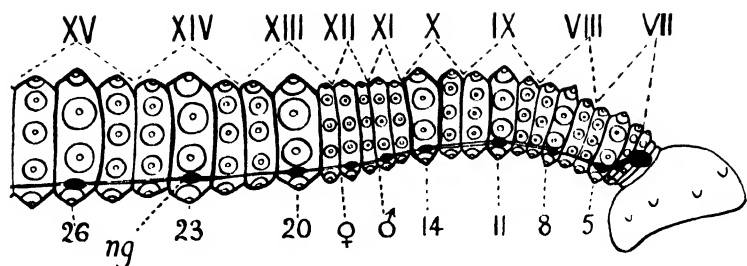
#### REFERENCES

- HARDING, W. A., 1924.—Descriptions of some new Leeches from India, Burma, and Ceylon *Ann. Mag. Nat. Hist. Ser. 9*, vol. XIV, pp. 489-499, Plates IX-XV.
- SCRIBAN, J. A., and AUTRUM, H., 1928-34 - Hirudinea, in Kukenthal-Krumbach's *Handb. d. Zool.*, vol. 2 Berlin, 1928-34.

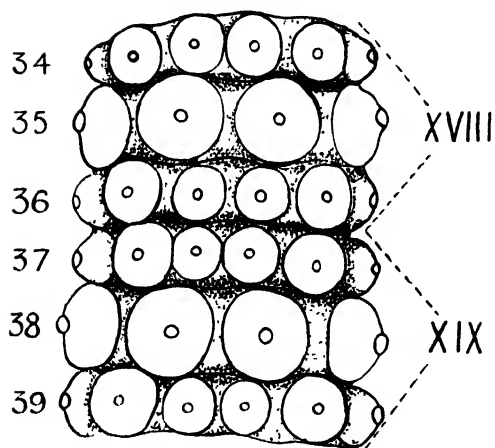
## PLATE V

### *Pontobdella verrucosa* n. sp.

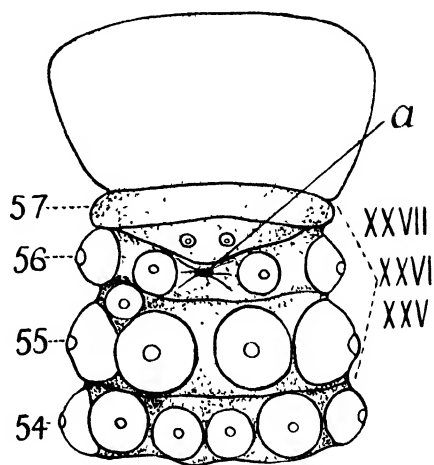
- FIG. 1.--Diagrammatic lateral view of leech showing annulation of anterior somites and the position of the nerve ganglia n.g. ganglion of somite XIV
- FIG. 2.- Dorsal view of two typical somites (XVIII and XIX) showing arrangement of tubercles.
- FIG. 3.- Dorsal view of annuli 54-57 showing position of anus, (a).
- FIG. 4.—Egg capsule viewed from above showing the aperture (ap.) through which the young leech has emerged and the disc (d) which it has forced out.
- FIG. 5.- Leech in a coiled-up position over its egg-capsules



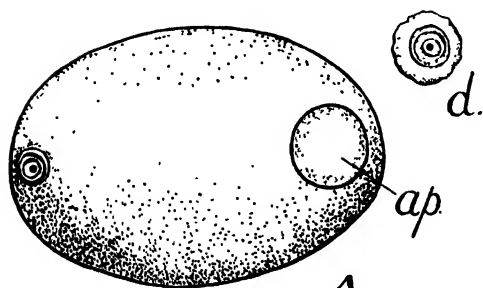
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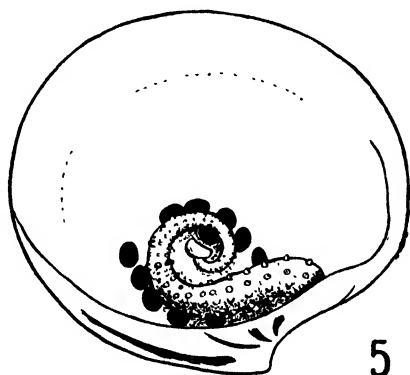
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4



5

## PLATE VI

*Pontobdella verrucosa* n. sp.

FIG. 6.—Photograph of leech (in alcohol). x 2.

FIG. 7.—Photograph of shell with egg-capsules of leech. x 3/2.



Fig. 6.

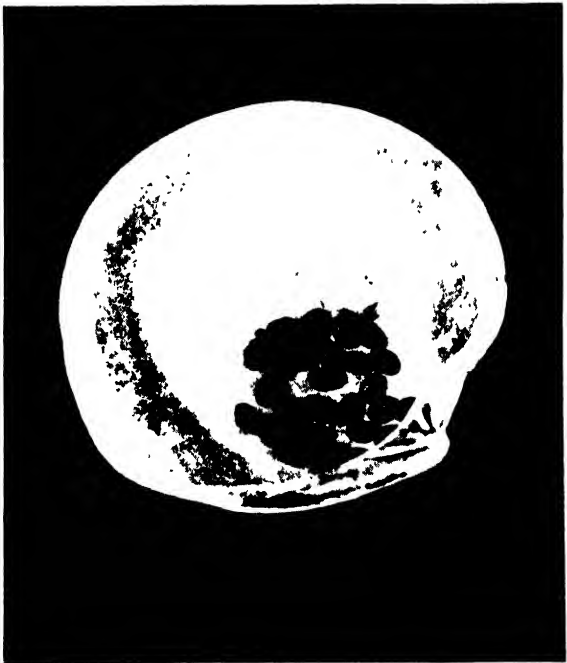


Fig. 7.



# Observations on Some Tasmanian Fishes

## Part V

By

E. O. G. SCOTT

(Read 10th November, 1941)

### PLATE VII

The present paper follows the general plan of previous contributions under the same title (1934, 1935, 1936, 1939): the term Fishes is interpreted broadly to include Selachians.

The dimensions standard length and total length are represented throughout by the symbols LS, LT, respectively.

Registration numbers are those of the Queen Victoria Museum, Launceston.

### Family GALEIDAE

Genus *Carcharhinus* Blainville, 1816

*Carcharhinus brachyurus* (Günther, 1870)

(Plate VII)

- ?*Galeolamna greyi* Owen, *Descr. Cat. Osteol. Roy. Coll. Surgeons*, 1, 1853, p. 96. ?*Id.* Whitley, *Rec. Aust. Mus. Sydney*, 1932, xviii, 6, p. 324. ?*Id.* Whitley, *Fish. Aust.*, 1, 1940, p. 102, fig. 88, no. 4 (not fig. 88, no. 5) and fig. 95, and p. 273, fig. 303 (not fig. 5)
- Carcharias brachyurus* Günther, *Cat. Fish. Brit. Mus.*, viii, 1870, p. 369 (specimens *c* and *d* doubtful)
- Not *carcharias brachyurus* Waite, *Rec. Aust. Mus. Sydney*, vi, 3, 1906, p. 226, pl. xxxix.
- ?*Carcharhinus macrurus* Waite, *Rec. S. Aust. Mus. Adelaide*, III, 3, 1927, p. 224 ?*Id.* McCulloch, *N.Z. Journ. Sc. Tech.*, vi, 5-6, 1924, p. 261, fig. 4.
- ?*Carcharhinus brachyurus* Waite, *Fish. S. Aust.*, 1923, p. 27 and fig.
- ?*Carcharhinus macrurus* Waite, *Rec. S. Aust. Mus. Adelaide*, III, 3, 1927, p. 224 ?*Id.* Phillipps, *Mem. Aust. Mus. Sydney*, v, 1, 1929, p. 10 (South Australian record only). Not *Carcharias macrurus* Ramsay and Ogilby, *Proc. Linn. Soc. N.S.W.*, (2), II, 1, 1887, p. 163 and p. 624. Not *Carcharhinus macrurus* McCulloch, *Proc. Linn. Soc. N.S.W.*, XLVI, 4, 1921, p. 457, pl. XXXVII, figs 1-4.
- ?*Carcharhinus lamia* Phillipps, *N.Z. Journ. Sc. Tech.*, VI, 5-6, 1924, p. 260 and fig. Not *Carcharhinus lamia* de Blainville, *Bull. Sci. Soc. Philom.*, 1816, p. 121.
- Galeolamna brachyurus* Whitley, *Fish. Aust.*, 1, 1940, p. 102, fig. 97.

**Record.** A mounted Tasmanian *Carcharhinus* that has been in the Museum collections for over forty years is here provisionally determined as *C. brachyurus* (Günther).



First record for Tasmania.

*Remarks.* The systematics of this genus are in a parlous state. To the known handicaps that limit our knowledge of several species to information based on casts, disassociated jaws, or juvenile (even foetal) individuals, I may add two further complications—first, that information received (*in litt.*, 6/8/'37) from Mr J. R. Norman, Ichthyologist, British Museum, Natural History, leads me to suspect that Günther's type-specimens of *C. brachyurus* may not be conspecific; secondly, that tables of dimensions of specimens accessible to Waite, kindly furnished by Mr H. M. Hale, Director, South Australian Museum, Adelaide, appear to suggest that certain features commonly accepted as diagnostic criteria may be subject to a degree of individual variation hitherto unrecognized. In view of the urgent need for additional data, a description and figure of the present specimen are here given.

*Description.* Body moderate, fusiform, its depth at pectoral origin 7.9, at first dorsal origin (max. depth) 6.4, in length to origin of lower lobe of caudal; or 10.5, 8.6, respectively, in LT. Length to vent 1.5 in LT.

Head (to first gill-slit) 6.6 in LT; postorbital portion slightly, preorbital portion strongly, depressed. Snout 2.4 in head; obtusely pointed in horizontal plane; in profile acute, with tip about at, or slightly above, level of superior border of orbit. Preoral length 1.4 in width of mouth, which is 2.0 in head, and about twice length of mouth. A short indistinct groove extending forward on each side of gonidial angle. Nostril fairly large; near, but not quite reaching, inferolateral margin of snout; length to it 1.5 in preoral length, 1.3 in interarial distance. Eye about 2.5 in height of first gill-slit, about 10.6 in head; its anterior margin barely in advance of middle of mouth. Measured obliquely, distance from anterior margin of eye to tip of snout is about 1.3 in distance from posterior margin of eye to first gill-slit. Last two gill-slits above base of pectoral: fifth subequal to first, about 0.7 of third.

About 30 teeth in upper jaw (those in lower jaw inaccessible). Anterior teeth of upper jaw (Plate VII, fig. 3) as long (11 mm.) as high, erect, or slightly recurved: base compressed, half as high as long, its inferior margin so boldly excavated as to suggest incipient bifurcation: crown compressed, biconvex: both margins obtusely crenulated throughout their entire length; along borders of the crown the crenulations subrectangular, closely apposed, along borders of the base, particularly posteriorly, more distinctly separated, with a tendency to become bilobed or trilobed, and more acute.

Pectoral large, narrow, acuminate, with a pronounced postaxial internal flap; its length rather more than twice its maximum width, 3.7 times its width at middle, 1.2 in length to its origin, the latter being 1.8 times as far from tip of snout as from origin of first dorsal. First dorsal moderate, anterior border gently sigmoid, posterior angle produced as an acute lobe more than one-fifth as long as base of fin; its origin, located at 0.32 of LT, nearer to tip of snout than its termination is to origin of lower caudal lobe; its base half length of pectoral, 1.3 times its own vertical height. Interdorsal space 0.8 of length to origin of first dorsal, 3.3 times distance between termination of second dorsal and origin of upper caudal lobe. Second dorsal small, low, posterior angle produced into a slender lobe two-thirds as long as base of fin; its origin, located at 0.66 of LT, slightly behind level of anal origin; its base 2.5 in base of first dorsal, 2.2 times its own vertical height. Ventral subquadrangular; its origin, located at 0.49 of LT, slightly nearer to anal origin than to first dorsal origin; its base a little longer than its anterior border. Claspers subcylindrical, extending about two-thirds of the distance between their origin and anal origin. Anal small, having the appearance of being composed of

two lobes, the oblique, moderately acute anterior one about twice as wide as the slender, almost horizontal lanceolate one; its origin, located at 0.65 of LT, slightly nearer to origin of lower caudal lobe than to termination of ventral base; its base subequal to base of second dorsal, 1.8 times its own height. Caudal moderate, set (perhaps as result of mounting) only slightly obliquely to main axis of body: upper lobe originating at 0.77 of LT, about an eye-diameter behind origin of lower lobe; its terminal inferior flap, near free margin of which, at 0.6 of length of flap, the downwardly curving ceratral column terminates, one-fourth length of lobe: lower lobe broad, obscurely pointed, with anterior border strongly convex, subequal to base of first dorsal, posterior border concave. Apparently a pit present at base of each caudal lobe.

Lateral line system appears to originate at level of middle of pectoral base, about one-sixth of depth of body below dorsal profile, and, proceeding caudad, sweeps gently and evenly down till on caudal peduncle it is equidistant from dorsal and ventral profiles; the oblique inferior tubules, of which there are 24 below first dorsal base, average twice as long as their interspaces.

General colour dark brownish grey (perhaps originally slaty) above, gradually lightening to palish grey below. No indications of dark tips to any of the fins.

Described and figured (Plate VII) from a mounted male specimen (Q.V.M. Reg. No. 962 y) of LT 2835 mm., and 2137 mm. long to origin of lower caudal lobe; caught in the River Tamar by G. T. Collins and R. J. Irvine in 1897.

### Family MYLIOBATIDAE

#### Genus *Myliobatis* Cuvier, 1816

#### *Myliobatis australis* Macleay, 1818

*Myliobatis australis* Macleay, *Proc. Linn. Soc. N.S.W.*, VI, 2, 1881, p. 380

This species is common, at any rate in summer, on Northern Tasmanian beaches, where it is a source of much inconvenience in seine-netting.

Females probably exceed males in size. Of seven specimens caught at Ulverstone in January, 1941, four females measured (width of disk, in mm.) 1022, 1050, 975, 866; three males 814, 780, 850. The smallest female and largest female thus exceeded the largest male by 2%, 24%, respectively, and the average value for females that for males by 20%. In both sexes length of tail slightly exceeds combined length of head and body, which is 0.5-0.6 of width of disk.

### Family ANGUILLIDAE

#### Genus *Anguilla* Shaw, 1803

#### *Anguilla australis* Richardson, 1841

*Anguilla australis* Richardson, *Proc. Zool. Soc. London*, IX, 1841, p. 22.

A xanthic specimen of LS 525 mm., dorsal index (Schmidt, 1928) 3.8, was caught in the Macquarie River, at *Rokeby*, on 21st December, 1938, by Mr C. Willoughby. Xanthism is virtually complete, extending even to all the fins, and being not evident only in the eye; and is tolerably uniform, with, however, some tendency towards the assumption of a deeper, more orange tint above the lateral line.

## Family AULOPIDAE

Genus *Aulopus* Cloquet, 1816*Aulopus purpurissatus* Richardson, 1843

*Aulopus purpurissatus* Richardson, *Icones Piscium*, 1843, p. 6, pl. ii, fig. 3.

*Aulopus milesii* Cuvier and Valenciennes, *Hist. Nat. Poiss.*, XXII, 1849, p. 385.

**Record.** A male specimen (Q.V.M. Reg. No. 1939. 119) of LS 279 mm. was caught at Ulverstone on 2nd November, 1939, and donated to the Museum by Mr F. Stephens. Two other individuals have since come to hand—a male (Q.V.M. Reg. No. 1940. 210), of LS 351 mm., from Blue Rock, Flinders Island (Mrs V. T. Hammond, 14th May, 1940), and a female (Q.V.M. Reg. No. 1941. 211), of LS 370 mm. from Rowella, West Tamar (Mr T. Cannon, 20th May, 1941).

Lord and Scott (1924, p. 35) note this species, but remark 'it is doubtful if' it 'can be classed as a Tasmanian form', and do not include it in their definitive list: not recorded as Tasmanian in the Check-List. The specimens here noted thus appear to provide the first definite records for Tasmania.

**Remarks.** Sexual dimorphism is well-marked. Taking the length of the 1st (simple) dorsal ray as unity, the relative lengths of the 2nd, 3rd, 4th rays are: smaller male 4.7, 4.3, 2.0; larger male 6.1, 3.0, 2.6; female 2.3, 2.0, 1.9. In the males the length of the two elongated rays (2nd, 3rd), relative to length of 1st ray, is thus 2.1 times the value for the female.

In the Ulverstone specimen the enlarged dorsal rays bear secondary rays, not unusual in this species, the 2nd ray (103 mm. long) giving rise, at 54 mm. from its base, to a sub-ray 7 mm. in free length, the 3rd ray (93 mm. long) giving rise, first, at 45 mm. from its base, to a double sub-ray 1.5 mm. in free length, and, secondly, at 45 mm. from its base, to a single sub-ray 7 mm. in free length: all these secondary rays originate from the posterior surface of the primary ray.

The female is of interest in having 14, instead of the usual 13, rays in the anal.

## Family HYPOPLECTRODIDAE

Genus *Nannoperca* Günther, 1861*Nannoperca australis* Günther, 1861

*Nannoperca australis* Günther, *Proc. Zool. Soc. London*, 1861, p. 116, pl. XIX, fig. 2.

*Microperca tasmaniae* Johnston, *Pap. Proc. Roy. Soc. Tasm.*, 1882 (1883), p. 110; and *ibid.* 1890 (1891), p. 30.

*Nannoperca tasmaniae* Lord, *Pap. Proc. Roy. Soc. Tasm.*, 1922 (1923), p. 67. *Id.* Lord and Scott, *Synopsis Vert. Anim. Tasm.*, 1924, pp. 10 and 54. *Id.* McCulloch, *Mem. Aust. Mus. Sydney*, V, 1929, p. 157. *Id.* Scott, *Pap. Proc. Roy. Soc. Tasm.*, 1934 (1935), p. 66.

**Status.** In a key to the genus McCulloch and Waite (1918) failed to distinguish between *N. australis* and *N. tasmaniae*, and later Waite (1921) listed Johnston's species as a queried synonym of Günther's: the implied identity, probably based on the consideration of descriptions, is not accepted in the Check-List.

A comparison of Tasmanian specimens from Mella and Victorian specimens from Kororoit Creek, Seaholme, fails to reveal any constant differences of specific value.

*Tasmanian Distribution.* Johnston's original comment (1883) 'abundant in the rivers of the South and North Esk', virtually repeated in his memoranda redacted by Whitley (1929, *a*), was formerly interpreted by me as representing all that was known of the Tasmanian distribution, and I called attention (1936) to a record from the Rubicon River at Dunorlan: numerous specimens have since been collected (April, 1936) by Mr B. Burnley in drains at Mella. I find, however, I have overlooked a short paper by Johnston (1888) on the fauna of King Island, in which he incidentally notes this species 'also inhabits the waters of the northern rivers of Tasmania'.

*Juvenile.* Numerous juvenile specimens were obtained by Mr H. J. King in November, 1941 from a pool at Perth. In an individual of LS 11.1 mm. (Q.V.M. Reg. No. 1941. 356) assumption of the adult facies, including scale-formation, was virtually complete, save for the attainment of only an elementary stage of pigmentation, which permitted a clear view of the beating of the heart.

### Family RHOMBOSOLEIDAE

#### Genus *Ammotretis* Günther, 1862

##### *Ammotretis tudori* McCulloch, 1914

*Ammotretis tudori* McCulloch, *Biol. Res. Endeavour*, ii, 3, 1914, p. 125, fig. 9

Waite (1923) observes 'as five specimens are known, all exhibiting' the peculiarity that the first ray of the small left pectoral bears a large fleshy knob at its tip, 'it cannot be looked upon as an abnormality'. McCulloch (1914) thought it probable the species would 'be found to be sufficiently abundant to form a valuable addition to the list of edible Australian flounders'.

In the course of fairly extensive netting carried out at Ulverstone in January, 1941, I found *A. tudori* abundant, perhaps one in three specimens of flounders caught belonging to this species. Curiously enough, however, it apparently does not reach the local market; at any rate, I have never observed it displayed in Launceston fish-shops.

### Family POMACENTRIDAE

#### Genus *Parma* Günther, 1862

##### *Parma viola* Whitley, 1929

*Parma viola* Whitley, *Mem. Queensl. Mus.*, IX, III, 1929, p. 231, pl. XXVIII, fig. 2.

Known only from the holotype, of LS 170 mm., forwarded in 1904 from this Institution to the Australian Museum, Sydney, where it remained (Whitley, 1929, *b*) for a third of a century labelled *Glyphisodon victoriac*. The receipt on 20th July, 1940 of a second specimen, of LS 154 mm. (Q.V.M. Reg. No. 1940. 292), caught at George Town, not only affords information on minor variations in proportion, but provides the first available data on coloration.

*Proportions.* Depth of body 1.9, of caudal peduncle 6.0, in LS. Head 3.7 in LS. Eye 1.2 in snout, 1.6 in interorbital space, 1.7 in head. Longest dorsal spine (5th, 6th) 1.8, longest dorsal ray (6th) 1.2, second anal spine 2.0, longest (8th) anal ray 1.4, longest (4th) pectoral ray 0.9, longest (2nd) pelvic ray 1.1, in head. Radial formulae agree with those of holotype.

*Coloration.* General colour of body above midlateral line bronzy brown, becoming purplish in parts, especially towards base of caudal; below midlateral line dingy pearl, with some purplish flushes. Head in general dark bronze; snout and nape dark brown, the latter almost black; scaleless marginal strip of preoperculum pearl, with pale bluish iridescence; operculum very dark brown anteriorly, becoming pearly brown at middle, posteriorly dingy silver with marginal streak of dark brown; lips dark brown; immediately below lower lip, a small patch of bright bronze, followed by two oblique chin-bars of silver, the first reaching nearly to angle of mouth, the second, whose width is subequal to its distance from the first, extending on to anterior portion of preoperculum; a hemispherical patch of pale copper arising from infero-anterior border of eye; a subrectangular patch of bluish purple shortly below, and partly in advance of, eye: pupil very dark blue, iris almost black; buccal cavity, including tongue, whitish.

Spinous dorsal: membrane pale bronze, becoming pale olivaceous towards free margin; spines rather darker. Soft dorsal: membrane dark olive; rays slightly lighter. Anal: membrane dark olive, with faint submarginal band of paler olive; rays rather lighter, five or six of the posterior ones with narrow dark-brown cross bar at two-thirds of their length; spines peacock blue. Caudal: membrane dark, somewhat yellowish olive, with a narrow band (marginal mesially, submarginal laterally) of lighter, more yellowish colour; rays about concolorous with membrane. Pectoral: membrane almost hyaline, slightly greenish above; rays olivaceous, the upper somewhat more greenish, the lower somewhat more yellowish. Pelvic: membrane brownish olive; rays mostly whitish, the anterior one somewhat dusky distally; spine dark peacock blue.

## Family CORIDAE

### Genus *Austrolabrus* Steindachner, 1883

#### *Austrolabrus maculatus* (Macleay, 1881)

*Labrichthys maculata* Macleay, *Proc. Linn. Soc. N.S.W.*, vi, 7, 1881, p. 89.

*Record.* A specimen (Q.V.M. Reg. No. 1939. 162), of LS 84 mm., LT 106 mm., was secured in a trawl at the mouth of the River Tamar, at a depth of 10-20 feet, by Mr E. H. Smith on 2nd December, 1939.

First record for Tasmania.

*Coloration.* The description of the holotype, four inches long, from King George's Sound, was drawn up after preservation of the specimen in spirits, and Macleay's (1881) colour-notes are meagre, as also are those of McCulloch (1913), who figures a specimen, 140 mm. long, from St Vincent's Gulf, South Australia. The following notes were made on receipt, shortly after capture, of the present specimen. General colour pale yellowish-green, with purplish tinges on and near head. Four or five dark brownish spots, about half size of scale, or less, above pectoral. On head, particularly on chin, which is bluish green, and on operculum, a few narrow reticulated reddish-brown markings: narrow dark bar immediately behind posterior border of preoperculum. Pupil dark greenish. Iris bluish green, with very narrow internal annulus of gold. Pectoral with membrane hyaline, rays pale purplish. Pelvic yellowish green at base, thereafter dusky purplish pink: whitish band on 3rd-5th rays. Dorsal with dusky, somewhat purplish areas, which, near middle of fin, cover virtually the whole of the membrane, and are reduced, in front and behind, to a subtriangular region (broadest proximally) between each

two adjacent rays; membrane between 1st and 3rd rays dark purplish-brown, small spots and slips of yellowish at bases and flanking basal half of spinous rays; a conspicuous dark-brown, almost black spot, about two-thirds diameter of eye, centring on proximal half of penultimate ray. Anal much like dorsal, but without anterior dark purplish-brown area, and with smaller hinder blackish spot, located here almost wholly on membrane between last two rays. Caudal with indications of dusky subvertical bars.

### Family URANOSCOPIDAE

#### Genus *Kathetostoma* Günther, 1860

##### *Kathetostoma laeve* (Bloch and Schneider, 1801)

*Kathetostoma laeve* Bloch and Schneider, *Syst. Ichth.*, 1801, p. 47, pl. VIII.

*Stomach-contents.* A specimen of LS 246 mm. (Q.V.M. Reg. No. 1941. 91) netted near Rowella, River Tamar, by Mr T. Hinds on 27th February, 1941, had in the stomach two well-preserved specimens of *Ammotretis rostratus* Günther, 1862 of LS 70, 73 mm.; and two undigested, and two partly digested specimens of a flathead (?*Platycephalus bassensis* Cuvier and Valenciennes, 1829), the two former specimens measuring 60, 67 mm. in LS.

Fishermen state that this species secures its prey by leaping vertically, the leap frequently exceeding a foot.

### Family SCORPAENIDAE

#### Genus *Neosebastes* Guichenot, 1867

##### *Neosebastes nigropunctatus* McCulloch, 1915

*Neosebastes nigropunctatus* McCulloch, *Biol. Res. Endeavour*, iii, 3, 1915, p. 157, pl. xxx.

*Record.* A beach-dried, but readily determinable, specimen of LS about 280 mm. was collected by the writer at West Ulverstone in December, 1938.

First record for Tasmania.

##### *Neosebastes thetidis* (Waite, 1899)

*Sebastes thetidis* Waite, *Mem. Aust. Mus. Sydney*, iv, 1, 1899, p. 100, pl. xx.

*Sebastodes thetidis* Waite, *Mem. Nat. Club N.S.W.*, 2, 1904, p. 47.

Not recognized as Tasmanian in the Check-List. Apparently, however, it should be included in the local list, being noted in the *Endeavour* Report as being 'very abundant in waters of 60-100 fathoms deep off the eastern coast of Tasmania' (McCulloch, 1915, a): see also Lord and Scott (1924).

#### Genus *Scorpaena* Linné, 1758

##### *Scorpaena ergastulorum* Richardson, 1842

*Scorpaena ergastulorum* Richardson, *Ann. Mag. Nat. Hist.*, IX, 1842, p. 217.

Appears in all local lists as *S. cruenta* Richardson, 1842 (*ex* Solander MS; New Zealand). New Zealand and Australian examples are considered to be conspecific; and *S. ergastulorum* has line priority.

Genus **Helicolenus** Goode and Bean, 1895**Helicolenus papillosus** (Bloch and Schneider, 1801)

- Synanceja papillosus* Bloch and Schneider, *Syst. Ichth.*, 1801, p. 196: ex *Scorpaena cottoides* Forster MS.  
*Sebastes percoides* Richardson, *Ann. Mag. Nat. Hist.*, IX, 1842, p. 217: ex Solander MS. *Id.* Johnston.  
*Pap. Proc. Roy. Soc. Tasm.*, 1882 (1883), pp. 79 and 114: and *ibid.* 1890 (1891), p. 31. *Id.* Lord, *Pap. Proc. Roy. Soc. Tasm.*, 1922 (1923), p. 70. *Id.* Lord and Scott.  
*Synopsis Vert. Anim. Tasm.*, 1924, pp. 13 and 84.  
*Helicolenus papillosus* McCulloch, *Mem. Aust. Mus. Sydney*, v, III, 1929, p. 385.

The above table of synonymy covers the principal local references: for extra-Tasmanian references see McCulloch (1929).

McCoy (1879) observes 'Rather rare on the Victorian coast'. Not at all uncommon in Launceston and Hobart fish-shops. Average total length 250-300 mm.

Usually figured (*e.g.*, McCoy, 1879; Waite, 1923) with dorsal fin terminating at last ray. I find, however, perfect individuals normally have half, or more, of last dorsal ray connected by membrane to caudal peduncle.

## Family APLOACTIDAE

Genus **Aploactisoma** Castelnau, 1872**Aploactisoma milesii** (Richardson, 1850)

- Aploactis milesii* Richardson, *Proc. Zool. Soc. London*, 1850, p. 60 Pisces, pl. I, figs 1-2  
*Aploactisoma schomburgki* Castelnau, *Proc. Zool. Acclim. Soc. Vict.*, I, 1872, p. 244.

The two features on which Castelnau found *Aploactisoma*, a series of palatine teeth, and two teeth on an anterior median longitudinal ridge on the upper jaw, have been shown to be non-existent (McCulloch, 1915, *b*). However, differences in cephalic architecture, notably the presence across the cheek of a series of protuberances, instead of a continuous ridge as in the extra-limital genotype of *Aploactis* Temminck and Schlegel, 1843, *A. aspersa* (Richardson, 1845), perhaps warrant generic distinction of the Australian fish.

Whitley (1933) has recognized a New South Wales and Victorian subspecies, *A. milesii horrenda*, distinguished from typical *A. milesii* from Western Australia (type-locality King George's Sound) and South Australia (type-locality of *Aploactisoma schomburgki* St Vincent's Gulf) by larger size ('up to nearly 7 inches', as against 'to 5 inches'), deeper body, villi blunt, papillose (fine and pointed in typical subspecies), colour more uniform and darker brownish than in *milesii*. A Tasmanian specimen of LS 130 mm., LT 160 mm. (Q.V.M. Reg. No. 1939. 147), caught at Low Head, in 5 fathoms, by Mr G. P. Smith on 26th November, 1939, is intermediate in character between the two subspecies, having the fine villi, and lighter brown coloration with indistinct darker spots and marblings of *A. m. milesii* (but not the whitish spots usually described as occurring in the caudal region), and the deeper body (depth at vent 3.8, maximum depth 2.7, in LS), and larger size of *A. milesii horrenda*.

Fin-counts of the vertical fins of the Tasmanian specimen fall outside the range found by McCulloch (1915) in an examination of 8 specimens from New South Wales, South Australia, and Western Australia, the dorsal formula being xiv, 16, the anal i, 14.

## REFERENCES

- JOHNSTON, R. M., 1883. General and Critical Observations on the Fishes of Tasmania . . . *Pap. Proc. Roy. Soc. Tasm.*, 1882 (1883), pp. 53-144
- , 1888. Notes with respect to the Fresh Water Fishes, and the Land and Fresh Water Molluscs of King's Island. *Pap. Proc. Roy. Soc. Tasm.*, 1887 (1888), pp. 74-76.
- LORD, C. E., and SCOTT, H. H., 1924.—*A Synopsis of the Vertebrate Animals of Tasmania*. Hobart.
- MCCULLOCH, A. R., 1913.—Studies in Austrahan Fishes. No. 3. *Rec. Aust. Mus. Sydney*, IX, 3, 1913, pp. 355-389, pl. XII, and figs 54-55.
- , 1914.—*Biol. Res. Endeavour*, II, 3, 1914, pp. 77-165, pl. XIII-XXXIV, text-figs 1-15.
- , 1915a.—*Biol. Res. Endeavour*, III, 3, 1915, pp. 97-170, pl. XIII-XXXVII, text-figs 1-3.
- , 1915b.—Notes on, and Descriptions of Australian Fishes. *Proc. Linn. Soc. N.S.W.*, XL, 2, 158, pp. 259-277, pl. XXV-XXXVII.
- , 1929.—A Check-list of the Fishes Recorded from Australia *Mcm. Aust. Mus. Sydney*, V, I-III (index, pt IV, 1930)
- MCCULLOCH, A. R., and WAITE, E. R., 1918. Some New and Little-Known Fishes from South Australia. *Rec. S. Aust. Mus. Adelaide*, I, 1, 1918, pp. 37-78, pl. II-VII, text-figs 26-31.
- MCCOY, F., 1879. *Prodromus of the Zoology of Victoria*, dec. IV. Melbourne.
- MACLEAY, W., 1881.—Descriptive Catalogue of the Fishes of Australia. *Proc. Linn. Soc. N.S.W.*, V, I, pp. 1-138.
- SCHMIDT, J. S., 1928.—The Freshwater Fish of Australia. *Rec. Aust. Mus. Sydney*, XIV, 4, pp. 179-210, figs 1-14.
- SCOTT, E. O. G., 1934.—Observations on Some Tasmanian Fishes, with Descriptions of New Species. *Pap. Proc. Roy. Soc. Tasm.*, 1933 (1934), pp. 31-53, pl. VI-VIII, text-figs 1-2.
- , 1935. Observations on Some Tasmanian Fishes: Part II. *Pap. Proc. Roy. Soc. Tasm.*, 1934 (1935), pp. 63-73, pl. V.
- , 1936.—Observations on Some Tasmanian Fishes: Part III. *Pap. Proc. Roy. Soc. Tasm.*, 1935 (1936), pp. 113-129, text-figs 1-3.
- , 1939. Observations on Some Tasmanian Fishes: Part IV. *Pap. Proc. Roy. Soc. Tasm.*, 1938 (1939), pp. 139-159, text-figs 1-2.
- WAITE, E. R., 1921.—Catalogue of the Fishes of South Australia. *Rec. S. Aust. Mus. Adelaide*, II, 1, pp. 1-208, pl. I, text-figs 1-332.
- , 1923.—*The Fishes of South Australia in British Science Guild Handbooks of the Fauna and Flora of South Australia* Adelaide
- WHITLEY, G. P., 1929a.—R. M. Johnston's Memoranda relating to the Fishes of Tasmania. *Pap. Proc. Roy. Soc. Tasm.*, 1928 (1929), pp. 46-68, pl. II-IV.
- , 1929b.—Some Fishes of the Order Amphiprioniformes. *Mcm. Queensl. Mus.*, IX, III, 1929, pp. 207-246, pl. XXVII-XXVIII, text figs 1-4.



## PLATE VII

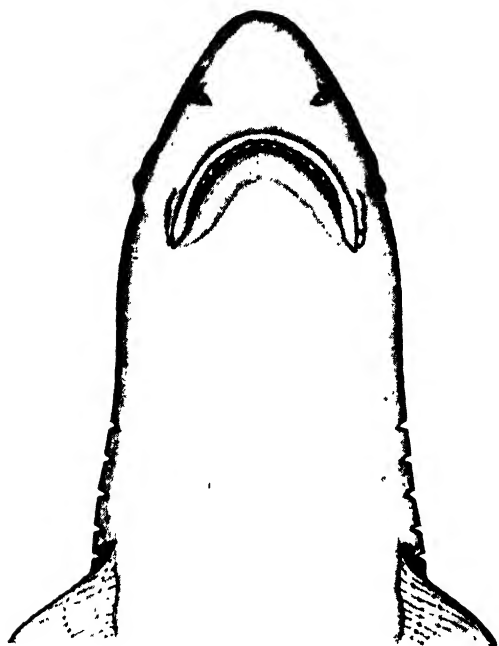
*Carcharhinus brachyurus* (Gunther, 1870)

A Tasmanian *Carcharhinus* (Q.V.M. Reg. No. 962 *y*) provisionally determined (see text) as *C. brachyurus* (Gunther, 1870). Male. Total length 2835 mm. Caught in River Tamar by G. T. Collins and R. J. Irvine in 1897.

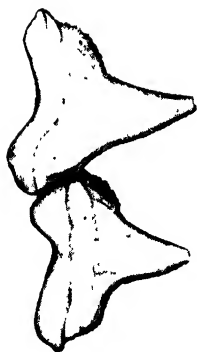
FIG. 1.—Lateral aspect. One-sixteenth natural size.

FIG. 2.—Ventral aspect of head. One-eighth natural size.

FIG. 3.—External aspect of two teeth from anterior part of upper jaw. Twice natural size.



2



3



1



## The Nitrogen Bases in Tasmanite Shale Oil

By

R. F. CANE\*

(Read 13th October, 1941)

### INTRODUCTION AND HISTORICAL

The type of nitrogen compounds produced during the retorting of oil shale, although essentially of a heterocyclic nature, depends on several factors, the chief of which are :—

- (i) The rate of heating:
- (ii) The retorting method:
- (iii) The absence or presence of air.

Although these 'tar bases' are mainly derivatives of pyridine and/or quinoline, other compounds of a pyrrole nature have been reported to occur, for instance Petrie (1905) recorded the presence of pyrrole compounds in the oil obtained from the torbanites of New South Wales, and accounts of the shale oil from Colorado giving the same reaction have been reported by McKee (1925).

The first systematic work on the nitrogen compounds in shale oil was that of Williams (1854) on Dorsetshire shale. Williams wrote that they burnt with a smoky flame, possessed a very bad smell, were soluble in alcohol and gave a blue precipitate with cupric nitrate. He isolated pyridine and some of its lower homologues. Garret and Smythe (1902) working on Scottish shale oil succeeded in isolating and identifying seven members of the pyridine series by oxidation to the corresponding acids with potassium permanganate and by the preparation of the aurichlorides of the bases.

Robinson (1879) recorded the presence of nitrogen compounds in Scottish shale oil bases, occurring in the fractions boiling between 270° C. and 390° C. He proved that they were dicyclic compounds of the iso-quinoline series. In reference to the formation of salts, Robinson writes 'attempts were made to get crystalline salts from the mixed bases; the double chlorides of platinum, gold, cadmium, mercury, lead and zinc were tried but without success, only resinous sticky masses being obtained. The same failure in getting crystalline salts was experienced when the bases were treated with sulphuric, hydrochloric, nitric and oxalic acids'.

Kogerman (1931) gives a detailed description of the methods used to obtain the purified bases from Estonian shale oil, and makes the statement that 'The pure bases, separated from the shale oil, formed a reddish liquid with a quinoline-like odour, specific gravity—0.9731 at 15° and  $n_D$ —1.539/19°'. He also states that,

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some of the higher bases failed to give crystalline salts, (cp. Robinson's remarks above), and, although he remarks that they belong to the pyridine and quinoline series, their presence was not confirmed. Eguchi (1927) has reported the presence of pyridine compounds in Fushun shale oil and identified methyl, dimethyl, and trimethylpyridines.

From the above brief summary it can be seen that aliphatic nitrogen compounds do not play an important role in the tar bases present in shale oil. These bases are, practically without exception, heterocyclic in structure and consist of alkylated pyridines and quinolines. The bases found in Tasmanite shale oil were typical of the above, members of the monocyclic and dicyclic series having been identified. However, a second type of base was found to be present, apparently belonging to the 'naphthenic base' group already discovered in Californian petroleum.

## EXPERIMENTAL

The material used in this investigation was not a representative crude oil in the true sense of the word, because very gentle pyrolysis was used in its production, the temperature being kept at all times below 420° C., a description of the properties of this oil has been given elsewhere by Cane (1941). The amount of tar bases present in the oil as determined by a modification of the Universal Oil Products Laboratory method No. C-78-40 was 3.2 per cent, while an examination of 10° C. cuts showed zero per cent in the lower fractions, with increasing amounts to nearly six per cent in the higher ones. The oil was extracted with successive batches of 10 per cent sulphuric acid, the acid washings removed, bulked, and then made alkaline with caustic soda, the supernatant oily layer allowed to settle on the top and then removed. The united bases were extracted with anhydrous petroleum ether and the etherial layer concentrated. The bases were again converted into their sulphates and the aqueous layer washed with petroleum ether to remove traces of hydrocarbons, and finally the purified bases liberated with dilute caustic soda solution. The isolated bases were orange in colour with a distinct greenish fluorescence, and possessed the following properties:—

Specific Gravity @ 20° C.	0.9717
Refractive Index @ 20° C.	1.5242
Nitrogen	8.41%
Sulphur	0.27%

Their smell was characteristic of the shale bases; i.e., a mixture of pyridine and quinoline together with a faint peppermint smell. The smell of the bases lingered on the hands, even after several washings, and the physiological action was quite pronounced, the vapour producing the most acute headaches across the eyes and at the nape of the neck.

## GENERAL REACTIONS OF THE BASES

- (I.) No carbylamine reaction.
- (II.) No crystalline quaternary ammonium salts with methyl iodide, but after standing for six months in a sealed tube a dark red tarry solid was formed.
- (III.) When diazotised and subsequently coupled with beta-naphol a dark green material was precipitated, and, when this was washed with sodium carbonate solution, a portion of the precipitate dissolved to form a deep red solution which dyed filter-paper orange. The residue from the sodium carbonate treatment was a green powder.
- (IV.) No Rimini's reaction and a very faint and doubtful Liebermann reaction.

(v.) A deep blue precipitate was formed with cupric nitrate.

(vi.) When the bases were reduced with sodium amalgam and alcohol for about 150 hours, a white water-soluble crystalline substance was precipitated.

*Distillation of the Bases.* The purified and dehydrated bases were distilled several times in all glass apparatus of special design, the column was silvered and vacuum jacketed, and the packing consisted of single turn wire helices. The following were the distillation results:—

Fraction No.	Boiling Range ° C.	Density @ 20° C.	Refractive Index @ 20° C	Average Mol. Wt. (1)	Nitrogen %	Vol. %
B1	165-213	0.9270	1.5070	128.3	10.89	5.7
B2	213-238	0.9518	1.5128	158.1	10.07	32.5
B3	238-250	0.9778	1.5299	169.9	9.39	22.0
B4	250-270	0.9803	1.5200	174.9	9.10	13.0
B5	270-290	0.9891	1.5349	171.8	8.89	13.7
B6				Residues and loss		13.1

The first fractions were colourless, but developed a light yellow colour on standing, while the higher fractions varied progressively from light yellow to a deep orange shade. All fractions deepened on standing, and it is interesting to note here the observations of Delaby and Hiron (1930) 'The alkyl quinolines are liquids of strong odour, light yellow in colour, and the colour becomes deeper, according to increasing molecular weight. Ethyl quinoline is nearly colourless when freshly distilled and under the same conditions butyl quinoline is straw yellow, but finally it assumes a brown red colour which deepens according to the time of preservation'.

*Fraction B1.*—When closely fractionated on a semi-micro scale, the following results were obtained. In this work the criterion for the acceptance of any one substance from the point of view of boiling point was that all of this fraction must distill between the boiling limits of 1° C.

Fraction No	Boiling Point.	Specific Gravity @ 18° C.	Refractive Index @ 20° C.	M P. of Picrate.	Nitrogen %
B1 (i)	173.2	0.9181	1.4984	154	11.33
B1 (ii)	198.4	0.9390	1.5004	N.O. (2)	10.91
B1 (iii)	206.4	0.9503	1.5054	N.O.	10.24

The above picrate and all others in this paper was obtained in the following manner:—The base was dissolved in 35 ml. of acetic acid, and to it was added two grams of picric acid contained in 5 ml. of 50 per cent acetic acid. When the crystals were deposited they were centrifuged from the mother liquor and crystallised from alcohol, washed, dried, and the melting point found.

(1) The molecular weight was determined by the cryoscopic method, using cyclohexane as the solvent, Muscarelli and Benati (1909).

(2) Not obtainable.

Analysis of the results of Fraction B1 (i) agree closely with reported ones for  $\gamma$ -collidine (2, 4, 6, trimethylpyridine), but it must be kept in mind that different authorities give very divergent values for these constants, and it has been noticed that they even differ by as much as 6° C. in the case of the boiling points of uncommon derivatives.

Portion of this fraction was oxidised with potassium permanganate in a normal laboratory manner, and among the oxidation products the presence of trimesitic acid was confirmed.

Trimethyl pyridine has already been found in Fushun shale oil by Eguchi (1927) and also has been isolated from lignite tar by Krey (1895). No success was obtained in the analysis of the Fraction B1 (ii). The preparation of crystalline precipitates was rendered impossible on account of the formation of thick orange tarry masses when the bases were treated in accordance with the technique described above. Every case resulted in the formation of this resinous mass, no matter how the formation of crystals was promoted, and it is interesting to note that Robinson made the same observation. He tried many inorganic salts, but the only result was 'resinous, sticky masses being obtained'. From later researches it seems probable that Robinson's, and the present, results were due, in part, to insufficient purification, but even Baily (1930), in the last few years, has had the same difficulty in the elucidation of the structure of the tar bases occurring in Californian petroleum. The last fraction, together with Fraction B2, seemed to be a transition stage between, or a mixture of, the mono-cyclic and di-cyclic bases. That the next fraction was of quinolinic nature is indicated by the sudden drop in nitrogen content and rise in molecular weight. An analysis of the boiling points and refractive indices might indicate the presence of hydrogenated quinolines, for as far as could be ascertained from the available literature none of the simpler alkyl pyridines have boiling points approaching any of the above. Even assuming that this fraction was composed of a complex mixture of highly alkylated pyridines, the refractive index is much too high to allow this consideration, e.g., propyl pyridine (b.p. 178° C.) has a refractive index of only 1.4934. Similar statements could be made with regard to the presence of hydro-quinolines. No less than nine alkyl deca- and tetra-hydro quinolines have boiling points approaching the above. It may be assumed that, if these fractions contain hydro-quinolines at all, the refractive index would surely rise as the fraction was reduced, and with this end in view a representative sample was dehydrogenated according to the procedure of Diels and Karstens (1927):—Five gms. of the base and 7 gms. of powdered selenium were heated for 38 hours at a temperature of  $185 \pm 1.5^\circ$  C. and the change in refractive index noted.

Refractive index before treatment	1.5126
Refractive index after treatment	1.5128

From a consideration of the hydro-quinolines, it can be calculated that the removal of four hydrogen atoms would cause an increase in the refractive index by an amount varying between 0.038 and 0.032, an increase which could be easily determined by refractrometric methods.

*Fraction B3.*—From this fraction onward it can be seen that there is a drop in nitrogen content, while the refractive index and molecular weight still rise. The per cent of nitrogen in trimethyl quinolines is 8.9 and molecular weight 171.1, which are in the range of the above fraction, but there are two important properties which require explanation, i.e., the low refractive index and density.

From the preliminary work on a bulk sample, the presence of quinolines was confirmed, but members of the series boiling in this range have refractive indices

greater than 1.58. It was shown, by treatment with selenium as before, that hydro-quinolines were not causing this discrepancy.

The work of Baily and his collaborators on the nitrogen-containing bases in Californian petroleum, has shown that another important type of tar base (naphthenic base) may occur, and it seems probable that similar compounds occur in Tasmanite shale oil. They are apparently tri-cyclic in structure and contain a piperidine nucleus. Baily's process of a cumulative extraction was applied to a representative fraction boiling between 240° C. and 290° C. It was dissolved in 1 : 1 aqueous hydrochloric acid and treated with chloroform according to the procedure developed by Baily. The aqueous layer containing the hydrochlorides of the quinolinic bases was washed with decreasing amounts of chloroform; the chloroform layer containing the naphthenic bases with decreasing amounts of water. Under this treatment the refractive index of the 'aromatic section' rose from 1.5321 to 1.5845, and the specific gravity increased to nearly unity after five stages of extraction.

From this it can be seen that we are dealing with exactly the same set of conditions experienced by Baily. Furthermore, the values of the refractive index and density are now within the range of the tri-methyl quinolines.

The extracted bases consisted of a sticky, semi-crystalline mass of light yellow colour with a greenish yellow fluorescence. The chloroform washings of the 'non-aromatic' bases were treated so as to isolate the free bases and their general properties found. They were brownish red in colour, with a blue fluorescence and refractive index of 1.4985. They gave the normal reactions characteristic of pyrrole compounds. It is believed that the structure of these bases is very complex, and no attempt was made to elucidate their structure. The quinolinic bases were converted into their picrates in solution buffered with sodium acetate, purified, and then heated with ammonia, from which the bases separated out as nearly solid masses. The bases were further purified by treatment with acetone, and then very carefully distilled in vacuo.

Fraction No	Temperature Range.	Refractive Index at 20° C.	Density at 15° C.	Molecular Weight.	Nitrogen. %
C1	244-245	1.5983	1.0641	142.0	9.59
C2	271-273	1.5903	0.9953	163.8	8.77
C3	277-279	1.5832	0.9307	177.4	8.01
C4	284-285	1.5742	0.9502	179.7	7.19

Analysing these results it can be seen that the first two fractions appear to contain methyl and di-methyl quinolines respectively, although their presence could not be confirmed. Tri-methyl quinoline was isolated from Fraction C3. This will be discussed later.

Great uncertainty exists with regard to the characteristics of these bases, and widely divergent values have been reported with regard to the higher alkyl quinolines; for example, four different values for the boiling point have been reported recently of 2-3-dimethyl quinoline varying between 261° and 273° C., so that in these analyses it has been attempted to class the quinolines according to the number of alkyl groups rather than to isolate individual compounds.



### THE PRESENCE OF THE QUINOLINE RING IN THE HIGHER BASES

A small quantity of the 'non-extracted' bases corresponding to Fraction C2 (no more of the purified substance being available) was oxidised very carefully with 2 per cent aqueous alkaline potassium permanganate solution for 15 hours. Quite an amount of trouble was caused by the bumping of the solution on account of the precipitated manganese dioxide. A small air leak introduced into the solution helped to minimise this difficulty and also served to inject sufficient permanganate solution during the operation. The resulting solution of pale stone colour was filtered and rendered acid. This was slowly distilled and the vapours condensed into aqueous ammonia solution, and the volatile organic acids examined (I.), the non-volatile matter was extracted with benzene in a Soxhlet extraction apparatus (II.), and the residue recrystallised from hot water (III.).

### THE VOLATILE ORGANIC ACIDS

The ammonium salts of the volatile organic acids were analysed, only the presence of acetic acid being confirmed in this solution, although a slight reducing action was observed, perhaps indicating the presence of formates, although they could not be confirmed.

### THE BENZENE SOLUBLES

The yellowish non-volatile mass was placed in a Soxhlet thimble and extracted with benzene for 38 hours, the residue being left in the thimble and extracted with water (III.). The benzene solution was evaporated in vacuo. All attempts to elucidate the structure of this portion were unsuccessful, but results tended to prove that this was due to the presence of the naphthenic bases, which, according to other investigators, are extremely stable, both to neutral or alkaline permanganate oxidation.

### THE WATER SOLUBLES

The water soluble material was concentrated and silver nitrate added; this caused an immediate dirty white precipitate, which was filtered off and purified. The amount of silver in the silver salt amounted to 58.6. Another portion of the silver salt was treated so as to liberate the free acid, no attempt being made to concentrate this on account of the difficulties encountered by Hantzsch (1882). The reaction with ferrous sulphate indicated a carboxylic acid in the *a* position. When this acid was distilled to dryness with lime, the odour of pyridine was observed.

It has been shown that the nitrogenous base present in the 271°-273° boiling range leads, on oxidation, to the production of pyridine carboxylic acids and, from the percentage of silver in the silver salt and basicity measurements, gives a molecular weight of 231.6 for the acid: this approximates fairly closely with methyl pyridine tri-carboxylic acid. Two of these carboxylic groups can be accounted for by the disintegration of the 'benzene' half of the molecule. This shows that there are two side chains in the 'pyridine' half of the molecule, one of which is obviously a methyl group.

From a study of the molecular weights of the base, it can be seen that we are dealing with either an ethylmethyl or trimethyl quinoline with perhaps a small percentage of higher homologues. However, assuming that trimethylquinoline is the major component, then there must be only one methyl group in the benzene half of the molecule. When the acid was heated and then coupled with resorcinol, a deep red substance was formed which had a distinct colour change from acid to alkaline solution; this compound, assumedly of the phthalein type, could only arise from an acid anhydride, necessitating two carboxyl groups in the ortho position to one another. Further proof of this orientation lies in the fact that it

was found, by using formaldehyde, that two and not three hydrogen atoms were replaced by carbinol, which, according to the results of Königs (1899), will only occur when the ortho position to the methyl radicle is substituted, that is, if the benzene ring is not acting as the ortho substituent.

*Phthalone formation*, requires a methyl or methylene group in the  $\alpha$  or  $\gamma$  position. A small amount of the base was heated with phthalic anhydride and zinc chloride for five hours at 165°; the resulting compound was a fine deep-red solid, which dissolved in boiling alcohol to give a crimson-orange solution.

The lack of formation of quarternary ammonium salts by methyl iodine may well be explained by reference to the results of Decker (1905), who found that ortho substituted quinolines exhibit steric hindrance, in that they do not form quarternary ammonium compounds with iodides. Oxidation of the base with chromic acid gave brownish needles, soluble in hot water, which sintered about 245°. The distillation of the barium salt gave a liquid ( $n_D^{20}$ -1.6053), which on oxidation with potassium permanganate, and distillation of the acid thus produced, gave quinoline itself.

#### SUMMARY OF THE BASIC BODIES

The only base isolated in the lower fraction was trimethylpyridine, the presence of which was confirmed by oxidation to the corresponding acid.

The compounds in the higher fractions consist, in the main part, of tertiary bases of the quinoline series, but results have shown that a second type of basic substance occurs, which possesses a low refractive index and probably contains a pyrrol nucleus in its structure.

The presence of hydrogenated quinolines was shown to be impossible from a study of the refractive indices before and after dehydrogenation experiment with selenium.

The presence of the quinoline ring was confirmed by oxidation, and from this it was shown that the alkyl radicles attached to the nucleus were nearly all methyl radicles.

The orientation of the methyl radicles in one fraction was elucidated, and it was found that one of them was in the 1; position, the other in the 2; position. The remaining radicle was in either the 5; or 8; position.

This investigation was carried out in the Department of Chemistry in the University of Tasmania, during the tenure of a Commonwealth Government Research Scholarship (1938 and 1939).

#### REFERENCES

- BAILY, J. R., 1930.—The Nitrogen Bases in Californian Petroleum *Jour. Amer. Chem. Soc.* Vol. LII, pp. 1239-1250, 1930.
- CANE, R. F., 1941.—Studies in Tasmanite Shale Oil. *Pap. Roy. Soc. Tas.* 1940 (1941) pp. 23-32.
- DELABY, and S. HIRON, 1930.—Sur les Alcoyl-Py-quinoleines *C.R. Acad. Sci. Paris.* Vol. CXCI, pp. 845-847, 1930.
- DECKER, H., 1905.—Ueber einige Ammoniumverbindungen Bildung und Zerfall quarterer Ammoniumsalze der inerten Basen. *Berichte Deutsch. Chem. Gesell.* Vol. XXXVIII, pp. 1144-1155.
- DIELS, O., and KARSTENS, A., 1927.—Über Dehydrierungen mit Selen. *Berichte Deutsch. Chem. Gesell.* Vol. LX, pp. 2323-2325.
- EGUCHI, T., 1927.—Basic Nitrogen Compounds in Fushun Shale Oil. *Bull. Chem. Soc. Japan* Vol. II, p. 176, 1927.
- GARRET, T. C., and SMYTHE, J. A., 1902.—The Bases contained in Scottish Shale Oil *Jour. Chem. Soc.* Vol. LXXXI, pp. 449-456, 1902. Vol. LXXXIII, pp. 763, 1903.
- HANTZSCH, A., 1882.—Ueber der Synthese pyridinartigen Verbindungen aus Acetessigather und Aldehydamoniak. *Annalen der Chemie.* Vol. CCXV, pp. 1-82, 1882.

- KÖNIGS, W., 1899.—Ueber die Einwirkung von Aldehyden auf solche Chinolinderivate welche eine Methyl oder Methylengruppe in  $\alpha$  oder  $\gamma$  Stellung enthalten. *Berichte Deutsch Chem. Gesell.* Vol. XXXII, pp. 3599-3612.
- KOGERMAN, P. N., 1931.—On the Chemistry of the Estonian Oil Shale Kukersite. *Bull. No. 3, University of Tartu*, May, 1931.
- KRMV, 1895.—*Berichte Deutsch Chem. Gesell.* Vol. XXVIII, p. 106, 1895.
- McKEE, R., 1925.—Shale Oil—A.C.S. Monograph No. 25. Chemical Catalog Company Inc. 1925.
- MASCARELLI, L., and BENATI, F., 1909.—Il cicloesano come solvente crioscopico. *La Gazzetta Chimica Italiana*. Vol. XXXIX, 1909, pt II, pp. 642-654.
- PETRIE, J. M., 1905.—The Mineral Oil from the Torbanites of N.S.W. *Jour. Soc. Chem. Ind.* Vol. XXIV, pp. 996-1002, 1902.
- ROBINSON, G. C., 1879.—New Bases of the Leucoline Series. *Trans Roy. Soc. Edin.* Vol. XXVIII, p. 561, 1879. *Trans. Roy. Soc. Edin.* Vol. XXIX, p. 273, 1880.
- WILLIAMS, C. G., 1854.—On the Volatile Bases produced during the destructive Distillation of the Bitumenous Shales of Dorsetshire. *Jour. Chem. Soc.* Vol. VII, pp 97-107, 1854.

# A Study of the Carbonization of some Tasmanian Timbers

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## 1.—INTRODUCTION

Most experiments on the carbonization of wood in closed retorts have been designed for the study of the distillates, and thus have usually been made on wood of irregular sizes, the temperature in the retort, but not in the wood, being measured. If it is a question of the production of good charcoal, it is desirable to know as much as possible about the progress of the carbonization reaction in the wood and the effect on the charcoal of such factors as log size and external temperature conditions. The present experiments have been made from this point of view on single cylindrical logs of varying sizes under controlled external conditions.

It is well known that the carbonization reaction <sup>(1)</sup> is exothermic and sets in at a temperature in the neighbourhood of 300° C. Gaseous and condensable distillates are given off during the reaction with a violence which will be shown below to vary greatly with the size of the log and the external conditions. If the heating is continued after the initial violent reaction is over, there is a steady, slow, evolution of volatile matter, accompanied by shrinkage of the charcoal, but there is no considerable change in the structure or hardness of the charcoal. Thus the final product may be regarded as produced in two stages, (I.) the carbonization reaction, and (II.) subsequent heating. In the experiments described below these two stages will be separated as far as possible. In §§ 2-4 the external temperature conditions are arranged so that their influence is small compared with that of the heat generated by the carbonization reaction itself, while cases in which the influence of external conditions predominates are considered in § 5. In §§ 2, 3, 5 only the temperatures developed are discussed, their influence on the nature of the charcoal is considered in § 8. The yield and nature of the species charcoal produced under low temperature conditions is given in §§ 4 and 8. The effect of continued heating after the carbonization reaction is over is considered in §§ 6-8.

The whole of §§ 2-9 refer exclusively to 'dry' wood, i.e., to wood of moisture content of, say, 25 per cent or less; the behaviour of green wood is discussed in § 10.

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(1) Throughout this paper 'carbonization reaction' is taken to refer to the violent initial reaction and not to the complete reaction giving the final charcoal. It is also convenient to speak of it as setting in at a definite temperature.

## 2.—THE TEMPERATURES ATTAINED DURING THE CARBONIZATION REACTION

In the present experiments wood is carbonized in single cylindrical pieces of varying diameters up to 7" and of lengths up to 2'. These are heated in an electrically heated retort, and the temperatures at various points of the log are measured by thermocouples. The gases given off are passed through a water-cooled condenser, and the quantities of condensate and of non-condensable gas are measured. The heating has usually been made in two stages, the first at a low current which gives a constant temperature of about 200° C. through the log after twelve hours; the current is then increased giving a slowly rising external temperature. This procedure has been adopted partly for convenience and partly to eliminate the effect of moisture and to treat all logs as far as possible on a standard basis.

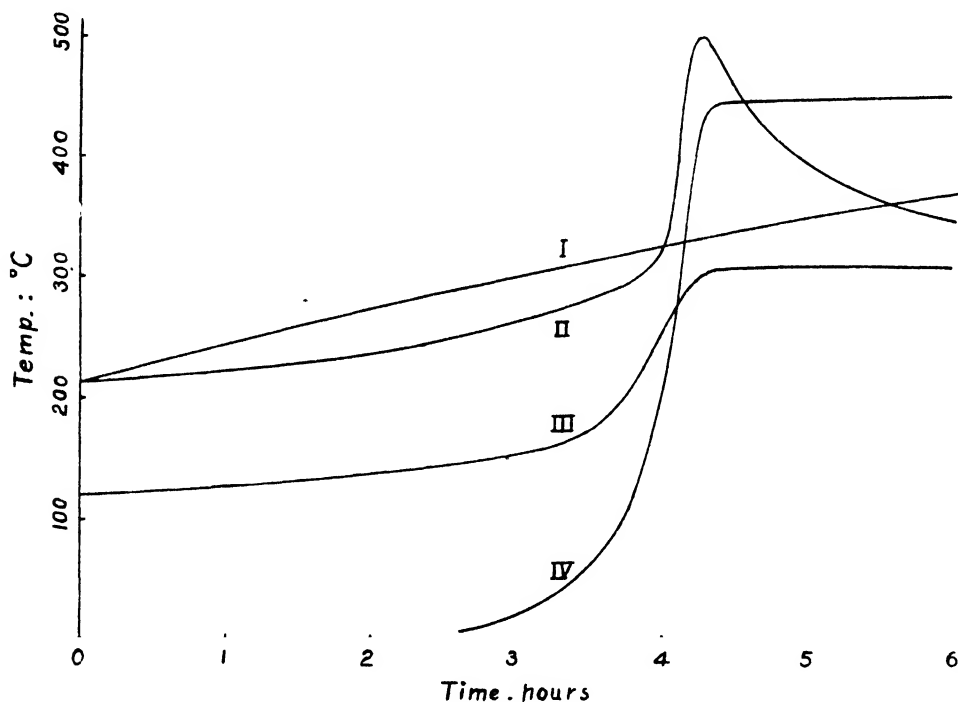


Fig. 1.

Typical behaviour under these conditions is shown in fig. 1 for a 6" diameter log of *E. linearis*, 13" long, weight 13.74 lb., moisture content 18.5 per cent. Curve I shows the retort temperature and Curve II the temperature at a point on the axis of the cylinder 6" from one end. The volumes of condensate and non-condensable gas given off are shown in Curves III and IV respectively; the total volume of condensate is 2.88 litres, and the total volume of gas given off is 452 litres. Although the observed temperatures might be expected to be affected by cracking in the wood or in the charcoal, the curves of fig. 1 are quite characteristic and surprisingly reproducible; as an example of this the maximum temperatures recorded in five experiments under the same conditions on 6" logs of *E. linearis* were 502, 500, 500, 495, 492° C.

It will be seen that, when the external temperature reaches a value in the neighbourhood of 300° C., the rate of flow of distillate increases and evolution of gas commences; these both fall off very sharply at the conclusion of the reaction. The most interesting point about fig. 1 is the magnitude and steepness of the temperature rise; these are greatest at the centre of the log, but they do not vary much over the cross-section of the log, except close to the surface; this matter is discussed in detail in § 3.

If the external temperature of the log is raised steadily, instead of in two stages as above, there is very little difference in the behaviour provided the external rate of increase of temperature is of the order of those in fig. 1. In the early stages of the heating the temperature at the centre of the log will lag considerably behind the outside temperature, so that, when carbonization commences, the rise of the internal temperature to its maximum will be steeper than that shown in fig. 1. The maximum temperature attained is unaffected.

TABLE I

Diameter (inches).	7	4.5	3	2.6	2.2	1.8	1.2
Max Temp (° C)	500	500	468	435	401	351	321
Max Rate of Increase of Temp (° C./min)	30	30	21	16	8	4	1.2
Average Volatile (%)	25	26	29	30	32	39	42

For the same external conditions the maximum temperature attained in the log varies with the diameter of the log, this effect is shown in Table I for *E. linearis* carbonized under the standard conditions described above. The cause of this effect cannot be settled until a more careful study of the thermal constants of charcoal has been made, it must be due in part at least to the relatively greater loss of heat from the smaller logs to the surroundings. The volatile contents given in Table I, and the nature of the charcoal produced, will be discussed in §§ 6 and 8. Of course not only the maximum temperatures, but also the maximum rates of increase of temperature and of flow of distillate, in fact the violence of the reaction, increase with increase of diameter.

### 3.—THE PROGRESS OF CARBONIZATION THROUGH THE LOG

Carbonization will set in at the point of the log which first attains the carbonization temperature; heat will be liberated at this point, and will be propagated through the log. For a long cylinder with external temperature constant along its length, the propagation will be radially inwards; this behaviour is approximated to if the outside of the log attains its carbonization temperature while the internal temperature is still fairly low. If there is not much temperature variation within the log, as is the case under the standard conditions of § 2, carbonization will commence at the hottest point of the length of the log and there will be a combination of radial and longitudinal propagation. This is shown in fig. 2 for a 6" log of *E. linearis*. In this experiment the temperature at the centre of the retort was a little higher than at the ends, and the temperature maximum is propagated from the centre towards the ends.

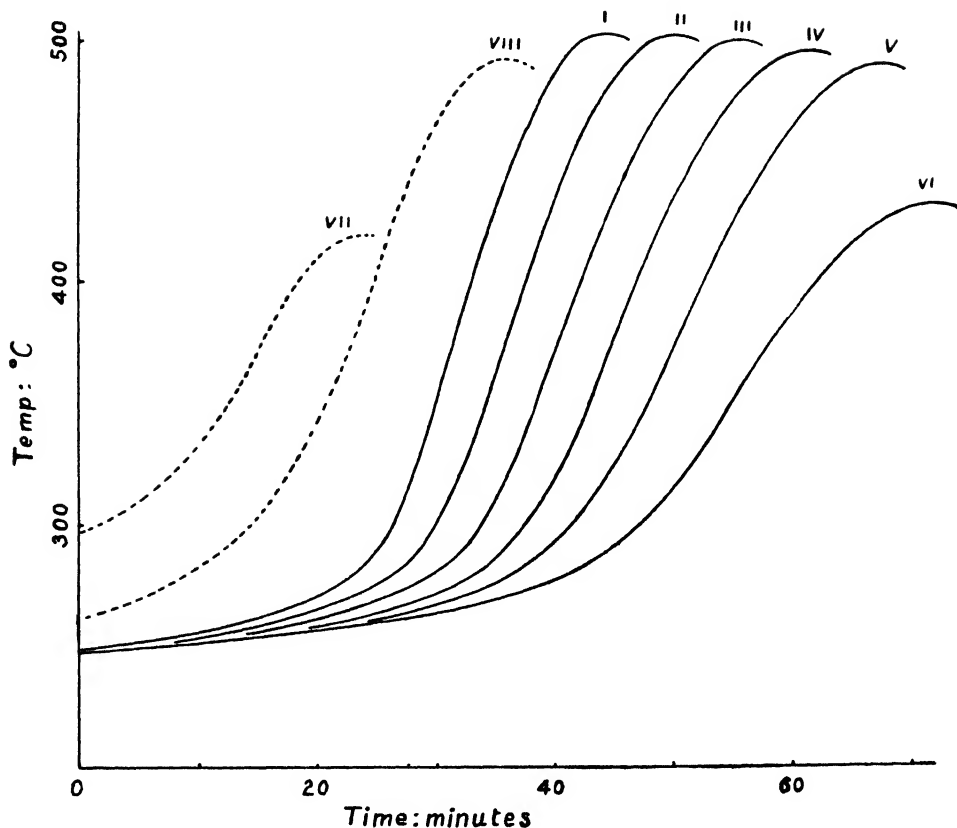


Fig. 2.

Curves I-VI show respectively portions of the temperature curves for points on the axis of the log distant  $5\frac{1}{2}$ ",  $4\frac{1}{2}$ ",  $3\frac{1}{2}$ ",  $2\frac{1}{2}$ ",  $1\frac{1}{2}$ ",  $\frac{1}{2}$ " from the end of the log; the isothermals can be seen to be travelling at a rate of about 1" in 4 minutes. Curve VII shows the temperature at a point just under the surface and  $5\frac{1}{2}$ " from the end; the temperature rise here is less in magnitude, and earlier, than at the corresponding point on the axis. Curve VIII shows the temperature at a point  $\frac{3}{4}$ " below the surface and  $5\frac{1}{2}$ " from the end; here, already, the maximum temperature attained is almost equal to that on the axis.

#### 4.—BEHAVIOUR OF DIFFERENT TIMBERS

Behaviour similar to that of fig. 1 for *E. linearis* is shown by all the timbers which have been examined. The variation between different species carbonized under the same conditions is shown in Table II. All timbers have been carbonized in cylinders 3" diameter and 15" long under the standard conditions referred to in § 2, the external rate of increase of temperature being about 0.5° C. per minute. The first column shows the maximum temperature attained on the axis, the second column its maximum rate of increase in ° C. per minute. The third column shows the maximum rate of flow of distillate expressed as the percentage given off per minute of the total distillate (from the dry wood). The yields of charcoal, stated

as the amount of dry charcoal of 15 per cent volatile <sup>(1)</sup> as a percentage of the dry weight of wood, are given in the last column. The number of experiments on which Table II is based varies from about 30 on *E. linearis* and *E. regnans*, which, with *Acacia dealbata*, have been most carefully studied, to one or two for the less important timbers. It is seen from Table II that all timbers examined give yields of the same order. Figures obtained for the same timber carbonized in different ways, and for green and dry timber (corrected as above for differences in volatile content), do not differ by more than two or three per cent.

TABLE II

Common Name.	Botanical Name.	Max. Temp. ° C.	Max. Rate of Increase of Temp.	Max. Rate of Flow of Distillate.	Yield. %
White Peppermint	<i>Eucalyptus linearis</i>	455	22	2.1	37
Black Peppermint	<i>E. salicifolia</i>	468	19	2.2	39
Stringybark	<i>E. obliqua</i>	472	22	2.1	36
Swamp Gum	<i>E. regnans</i>	465	19	2.2	36
White Gum	<i>E. viminalis</i>	463	14	2.8	36
Cabbage Gum	<i>E. pauciflora</i>	468	18	1.6	38
Black Gum	<i>E. ovata</i>	455	9	2.1	38
Blue Gum	<i>E. globulus</i>	435	16	1.3	36
Gum-topped Stringybark	<i>E. gigantea</i>	428	8	1.5	39
Victorian Red Gum	<i>E. rostrata</i>	364	3.5	0.9	43
Silver Wattle	<i>Acacia dealbata</i>	450	20	3.1	34
Black Wattle	<i>A. decurrens</i>	450	25	2.8	34
Prickly Wattle	<i>A. verticillata</i>	465	20	3.0	35
Blackwood	<i>A. melanoxylon</i>	442	12	2.0	38
Myrtle	<i>Nothofagus Cunninghamii</i>	430	8	2.0	35
She Oak	<i>Casuarina quadrivalvis</i>	450	13	2.1	36
Bull Oak	<i>C. rubrosa</i>	441	13	2.0	34
Sassafras	<i>Atherosperma moschatum</i>	440	12	2.2	34
Manuka	<i>Melaleuca</i> sp.	440	15	1.8	32
Wild Pear	<i>Pomaderris apetala</i>	414	8	3.4	34
Currijong	<i>Plagianthus sidoides</i>	460	24	3.5	34
Redwood	<i>Beyeria viscosa</i>	405	8	3.0	37
Honeysuckle	<i>Banksia marginata</i>	366	4	1.8	37
Dogwood	<i>Bedfordia salicina</i>	410	7	1.5	35
Tea Tree	<i>Leptospermum</i> sp.				32
Leatherwood	<i>Eucryphia Billardieri</i>				35
Celerytop Pine	<i>Phyllocladus rhomboidalis</i>				35

It will be seen that, while all timbers behave in the same way, there are considerable differences in the violence of the reaction. Roughly it may be said that high values of the maximum temperature, the maximum rate of temperature rise, and the maximum rate of flow of distillate are associated and form a 'violent' reaction; while low values, again, are associated to form a 'quiet' reaction. Thus

<sup>(1)</sup> The final temperature in these experiments is 350° C., and the volatile contents range from 25-35 per cent. The yields have all been reduced to 15 per cent volatile in Table II.



*E. linearis* shows a typical violent reaction, and *E. rostrata* <sup>(1)</sup> a very quiet one. A quiet reaction usually gives a solid charcoal in very large pieces; the charcoal from a violent reaction is much more broken. This question will be returned to later.

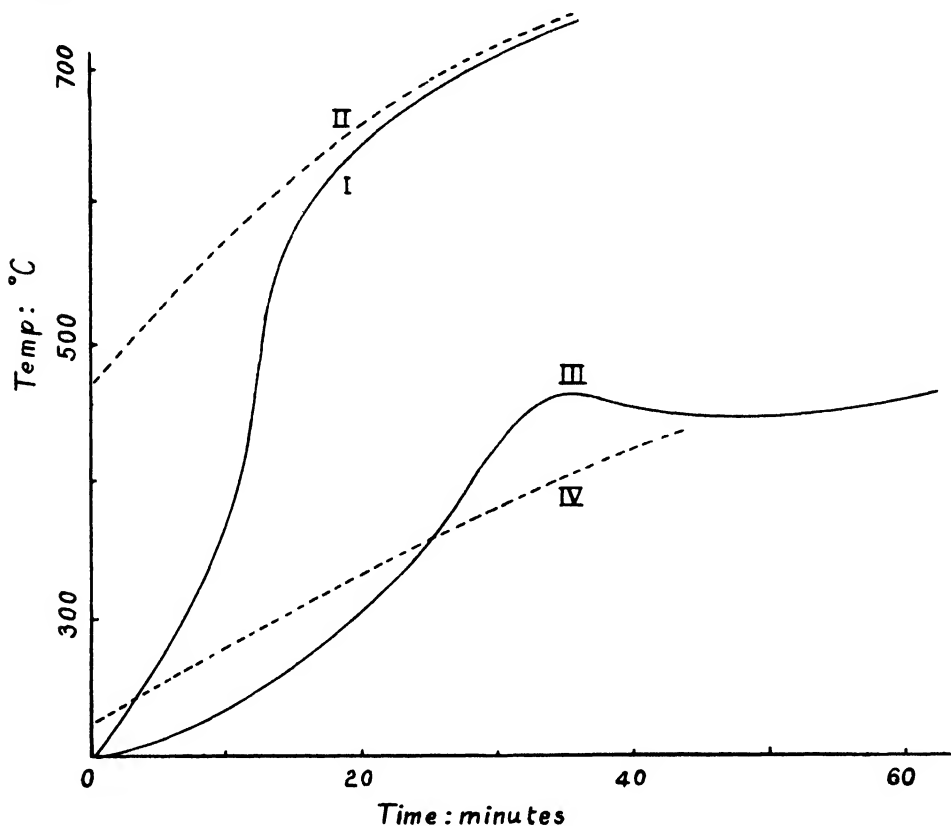


Fig. 3.

##### 5.—THE TEMPERATURE IN A RAPIDLY HEATED LOG

If the external temperature of a log is raised rapidly, instead of slowly as in §§ 2 and 3, there is still an increase of temperature in the interior due to the heat evolved during carbonization, but the maximum of fig. 1 is less pronounced or disappears. This is illustrated in fig. 3 for *E. linearis* 2" diameter; Curves I and III are portions of the axial temperature curves corresponding to the external temperature variations II and IV respectively. In Curve I the characteristic maximum of fig. 1 has disappeared; in Curve III it is still present, though not so marked. The maximum rates of increase of temperature are greater than those of Table I, their values being about 80° C. per minute for Curve I and 20° C. per minute for Curve II.

<sup>(1)</sup> Throughout this paper *E. rostrata* refers to a single piece of the timber sent from the mainland. It is discussed partly because the standard testing charcoal is made from this timber, and partly because of its extreme behaviour. The piece in question is apparently from the centre of a large tree and is very short in fibre.

## 6.—THE VOLATILE CONTENT

It has been shown above that the violence of the carbonisation reaction may vary very considerably with the log size and the external temperature conditions. If the charcoal is allowed to cool immediately the reaction is over, it would be expected that the product of a violent reaction would have a lower volatile content than the product of a quiet reaction. That this is the case is shown by the figures of Table I; in all cases the retort is allowed to cool (taking about 12 hours) after the reaction is over. Under these conditions, also, there is a noticeable variation of volatile content over the cross-section of the timber; its value is least at the centre and greatest at the outside. Typical figures for a 6" log of *E. linearis* are: outside 31 per cent, mid-radius 26 per cent, on the axis 24 per cent. Reasons for this variation are presumably (I.) that the temperature rise is greatest on the axis, (II.) that the wood on the axis is the last to carbonize, and (III.) that cooling is slower on the axis.

If heating is continued after the carbonization reaction is over, volatile matter continues to be evolved slowly, so that, if the charcoal is given a period of soaking at a final temperature, before being allowed to cool, the volatile content of the final product may be expected to depend on this temperature as well as on the violence of the reaction. Clearly, if the final temperature is less than the maximum temperature attained during carbonization, the resulting volatile content will depend in a complicated manner on both these temperatures and cannot be correlated with either. However, if the final temperature is greater than the maximum temperature<sup>(1)</sup>, and the charcoal is given a reasonable soaking at the final temperature, a volatile content is attained which depends mainly on the final temperature. The following figures for *E. linearis* with a final temperature of 500° C. will illustrate

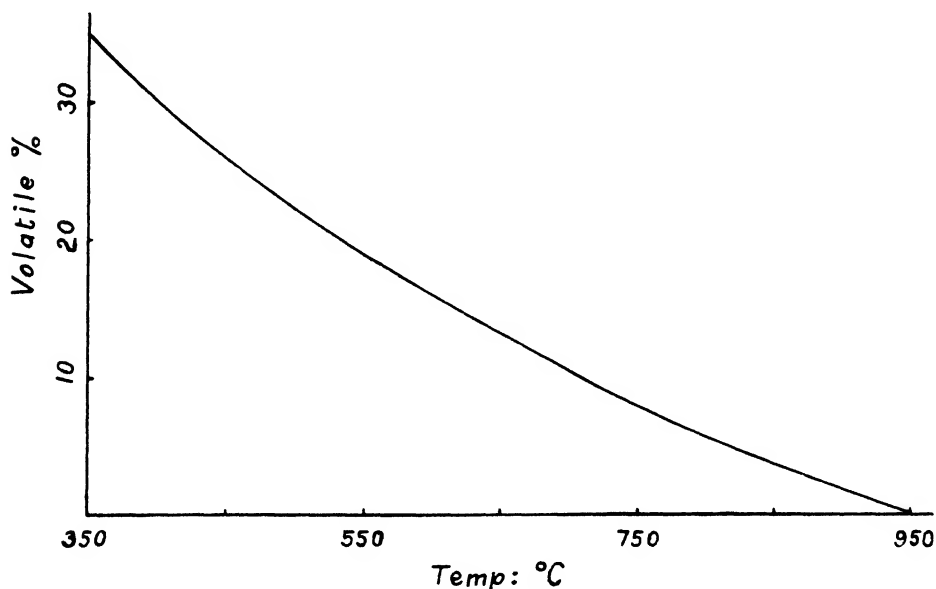


Fig. 4.

(1) To satisfy this condition for final temperatures less than 500° C., it is necessary to carbonize the wood in small pieces, cf. Table I.

this; they are for wood carbonized in various ways, e.g., strips, green wood, large dry wood, and reheated charcoal: with a 3-hour soaking at the final temperature, the figures obtained were 23, 23, 22, 22, 21 per cent, and, with a 12-hour soaking, 24, 23, 23, 23, 22, 20 per cent.

Fig. 4 shows the variation of volatile content with final temperature for *E. linearis* (the final temperature being greater than the maximum temperature attained during carbonization). The curves for *E. obliqua* and *E. regnans* are similar, but fall off rather more rapidly.

#### 7.—SHRINKAGE

The shrinking of charcoal during and after the carbonization reaction clearly plays an important part in the breaking up of charcoal during heating. While the amount of shrinkage in the carbonization of wood in large pieces may not be quantitatively the same as that in the carbonization of small pieces, the behaviour of the latter should give a good qualitative guide to that in the former. Accordingly, longitudinal shrinkages were measured on pieces 4" long by  $\frac{1}{2}$ " square, and radial and tangential shrinkages on trapezoidal pieces about  $\frac{1}{2}$ " thick and  $1\frac{1}{2}$ " square, with sides following the rays and rings. In all cases the wood has been carbonized slowly to avoid cracking during carbonization (for this see § 8). Values of the shrinkages, expressed as percentages of the dry length of the wood, are given in Table III for various final temperatures; they are to be regarded as typical values only, since there is a good deal of variation between experiments. In all cases the charcoal has been kept for three hours at its final temperature.

TABLE III

	<i>E. linearis.</i>	<i>E. regnans.</i>	<i>E. obliqua.</i>	<i>E. rostrata.</i>	<i>Ac. dealbata.</i>	<i>Sassafras.</i>
350° C. Long.	5	6	4	3	6	6
500° C. Long.	12	13	13	10	13	13
900° C. Long.	19	18	18	15	21	21
350° C. Rad.	12	20	14	7	13	19
500° C. Rad.	19	26	19	11	19	25
900° C. Rad.	25	33	26	20	29	34
350° C. Tang.	16	24	18	12	23	22
500° C. Tang.	23	29	22	17	30	28
900° C. Tang.	30	36	29	21	37	38

It will be seen that the radial and tangential shrinkages are much greater than the longitudinal, and that in all cases there is a considerable shrinkage on subsequent heating after the carbonization reaction is over. Thus, particularly when carbonization is propagated radially, and when external temperatures are fairly high, differential shrinkage may be expected to be the chief mechanism of the breaking up of charcoal into smaller pieces. Shrinkages for all timbers examined are seen to be of the same order, those for *E. rostrata* being lowest.

#### 8.—THE EFFECT OF EXTERNAL CONDITIONS ON THE NATURE OF THE CHARCOAL

In §§ 2-5 the temperatures attained in a log when carbonizing have been studied and have been found to be considerably influenced both by the size of the log

and the external temperature conditions. For example, it follows from Table I that for *E. linearis* it is possible only with small diameter wood and with a low rate of increase of external temperature to keep the internal temperature of the wood low and to produce a 'quiet' reaction. The nature of the charcoal produced by the experiments of Table I varies very widely; thus the 1.2" diameter wood yielded a very hard homogeneous charcoal, all in one piece; with the increase in diameter the charcoal commences to break up into small pieces, and also becomes more friable. The breaking up is presumably due to differential shrinkage caused by the increase of internal temperature. The increase of friability appears to be due in part to another cause, namely, the increasing violence of the reaction which causes the gases given off to burst small channels in the carbonizing wood for their escape. These channels appear as small cracks (') in the charcoal, and cause a great decrease in its strength.

It is reasonable to suppose that it is the rate of increase of temperature near the carbonization temperature that gives rise to a violent reaction. To determine the effect of rate of increase of temperature, experiments were made on strips  $\frac{1}{2}$ " square by 4" long, which could be heated rapidly in a small retort in a muffle. In Table IV for *E. linearis* the rates of increase of retort temperature, the violence of the reaction (as observed qualitatively from the evolution of distillates), and the nature of the charcoal are shown. The actual rates of increase of temperature in the wood will be greater than those shown in Table IV, but for such thin strips the difference will not be large.

TABLE IV

Rate of Temp. Rise ° C./min.	Reaction.	Charcoal
20	Very fast	Much broken
18	Fast	Less broken
15	Medium	Small cracks only
11	Slow	Practically solid
6	Very slow	Solid

It follows that, for production of best quality charcoal from small pieces of wood, a rate of temperature rise of about 10° C. per minute is critical. A rate of the same order might be expected to be critical in the interior of the timber, and, as a larger rate (20° C. per minute) is recorded in Table II for *E. linearis*, it seems that a certain amount of loss of mechanical strength is to be expected from this cause in timber of any size. The other timbers examined in this way are *E. obliqua*, *E. regnans*, *E. rostrata*, *Acacia dealbata*, and *Sassafras*. The first two eucalypts show behaviour practically identical with that of *E. linearis*. *E. rostrata* ('), *Acacia dealbata*, and *Sassafras* will stand a greater rate of increase of temperature without deterioration, and the former also shows a much smaller maximum rate of increase of temperature in Table II.

(<sup>1</sup>) These are not due to shrinkage of the wood in drying; check experiments of Table IV have been made with oven dried wood.

(<sup>2</sup>) It may be remarked that the experiments proposed by Miss Plante [*J. Council for Scientific and Industrial Research*, 14, 3 (1941)] in which wood is carbonized in strips 1" square will, for the reasons discussed above, not be a reliable guide to the mechanical properties of charcoal produced from larger logs, though experiments with *E. rostrata* might indicate that they were.

In cases such as those of § 5 in which the maximum rate of increase of temperature is very high, a very poor quality charcoal is produced.

#### 9.—PRACTICAL CONCLUSIONS

The most immediate practical application of these results is to carbonization in large retorts. It might be hoped that by a slow carbonization a very solid charcoal might be obtained; however, unless the wood is carbonized in small pieces, the improvement in quality is not very great.

The reason for the poor quality of open-pit charcoal is fairly clear, namely, the high external temperature which gives a violent carbonization reaction. Differential shrinkage will cause the subsequent breaking up of the charcoal.

In the Kurth continuous kiln the conditions seem to be very similar to those in the experiments above: most of the heat is obtained from the reaction itself, and the charcoal has some time to soak at the maximum temperature generated by the reaction. It may thus be expected to attain a temperature of 500° C. and to emerge with a volatile content from fig. 4 of about 22 per cent. Only *E. regnans* has been burnt in this kiln, and the observed volatile contents are about 15 per cent, in good agreement with the equivalent for *E. regnans* of fig. 4.

#### 10.—GREEN WOOD

The behaviour of green, and half dry, wood is entirely different from that previously described, for the following reason: if heating takes place at temperatures of the order of those occurring in charcoal burning practice, the wood checks severely while drying during the early part of the heating and splits up into flakes about  $\frac{1}{8}$ " thick, running radially inwards, separated by air spaces of much the same size. The sap wood alone remains solid. The flakes of wood carbonize as an assemblage of thin strips, rather than as a single piece, and thus their behaviour resembles that of small pieces of wood. The reaction is thus 'quiet', and the maximum temperature attained less than that for dry wood. For example, a 3" diameter piece of *E. linearis* of moisture content 66 per cent shows, under the conditions of Table II, a maximum temperature of 395° C., a maximum rate of increase of temperature of 7° C. per minute, and a maximum rate of flow of distillate of 1.4. The maximum rate of flow of gas is also much less for green than for dry wood.

We are indebted to the Tasmanian Technical Committee on Fuels, and to the C.S.I.R. grant to the University of Tasmania, for financial assistance.

# The Royal Society of Tasmania

## 1941

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**Patron:**

His Majesty the King.

**President:**

His Excellency Sir Ernest Clark, K.C.B., K.C.M.G., C.B.E.

**Vice-Presidents:**

E. E. Unwin, M.Sc., 1941.

H. Allport, LL.B., 1941, 1942.

**Council:**

W. H. Clemes, B.A., B.Sc., 1941, 1942, 1943.

L. Cerutti, B.A., Dip.Ed., 1941, 1942, 1943.

W. L. Crowther, D.S.O., M.B., V.D., 1941, 1942.

A. L. Meston, M.A., 1941, 1942.

V. V. Hickman, B.A., D.Sc., 1941.

A. N. Lewis, M.C., LL.D., 1941.

**Standing Committee:**

W. L. Crowther, E. E. Unwin, V. V. Hickman, J. Pearson.

**Hon. Treasurer:**

S. Angel.

**Hon. Editor:**

Joseph Pearson, D.Sc. (Manc.), D.Sc. (Liverpool), F.R.S.E., F.L.S.

**Auditor:**

H. J. Exley, M.A.

**Secretary and Librarian:**

Joseph Pearson.

## Annual Report

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The Annual Meeting was held in the Society's Room, Tasmanian Museum and Art Gallery, Hobart, on the 11th March, 1941.

The following Office-bearers were elected:—

Under the Society's Rules Mr. W. H. Clemes retired from the office of Vice-President, and Mr. Henry Allport was appointed in his place (retiring 1943).

Treasurer: Mr. S. Angel.

Under the Rules Mr. N. P. Booth and Mr. Henry Allport retired from the Council, and the following members of the Council were elected in their place:—

Mr. W. H. Clemes (retiring 1944).

Mr. L. Cerutti (retiring 1944).

The Council made the following appointments at its first meeting:—

Secretary and Librarian: Dr. Joseph Pearson.

Assistant Librarian: Mrs. Clive Lord.

Standing Committee: Dr. W. L. Crowther, Mr. E. E. Unwin, Dr. V. V. Hickman, and the Secretary.

The Council elected the following two Trustees to serve on the Board of Trustees of the Tasmanian Museum and Art Gallery and the Botanical Gardens in accordance with the amended Tasmanian Museum and Botanical Gardens Act:—  
Mr. W. H. Clemes and Mr. E. E. Unwin.

Nine meetings were held during the year (see proceedings for abstract of papers). In addition scientific papers were submitted for publication and have been printed in the present volume.

### *Library*

During the year 236 volumes were added to the Library in addition to a number of reports and pamphlets from British and foreign countries. The number of Institutions on the Exchange List for the year was 278, being made up of 130 British, 55 American, and 93 from other parts of the world. The Library now consists of 20,125 volumes.

The sum of £43 9s. 5d. was spent on books during the year, and the amount allocated as follows:—

	£	s.	d.
General Fund	6	15	4
R. M. Johnston Fund	16	15	11
Morton Allport Memorial Fund	14	18	6
Beattie Memorial Fund	4	19	8

In addition the Tasmanian Museum spent £3 8s. 6d. on books which have been placed in the Society's Library for safekeeping, and are available to members.

*Membership*

The Society consists of the following members:—

	1940.	1941.
Honorary Members	2	2
Corresponding Members	3	3
Life Members	7	7
Ordinary Members	227	210
Associate Members	6	5
	<hr/> 245 <hr/>	<hr/> 227 <hr/>

During the year 26 names were removed from the ordinary membership owing to deaths, resignations, &c., and 9 new names were added, including 1 from associate membership.

Also, 2 resignations were received from associate members and 1 member was transferred to ordinary membership, while 2 new members were added.

The Council regrets having to record the following deaths during the year:—Miss M. B. Adams, Mr. A. E. Blackman, Mr. W. F. D. Butler, Mr. H. N. Grant, Mr. J. J. Millen, Mr. R. S. Padman, Dr. A. W. Shugg.

*Printing of Papers and Proceedings*

Once again the Government has very generously printed the Papers and Proceedings. The Council wishes to record its appreciation of this assistance.

*Safeguard of Valuable Material*

During the year the Council considered the question of removing some of the Society's valuable manuscripts, documents, and other irreplaceable material to places of safe keeping. The Council asks for further assistance from members in this connexion.



## Abstract of Proceedings

10TH MARCH, 1941

### *Annual Meeting.*

The Annual Meeting was held in the Society's Room, Tasmanian Museum. The President, His Excellency the Governor, presided.

The following were elected Office-bearers and members of the Council for 1941:—Mr. Henry Allport was elected Vice-President in the place of Mr. W. H. Clemes, who retired under Rule 12; Mr. W. H. Clemes and Mr. Leonard Cerutti were elected in the places of Mr. N. P. Booth and Mr. Henry Allport, who retired under Rule 21; Treasurer, Mr. S. Angel.

Mr. H. J. Exley was elected Hon. Auditor in the place of Mr. Walter Taylor, who retired after many years of valuable service to the Society.

Mrs. J. D. Morris was elected a member of the Society.

Mr. M. W. F. Tweedie, of the Raffles Museum, Singapore, gave an illustrated lecture on the Natural History of Malaya.

7TH APRIL, 1941

A meeting was held in the Society's Room on this date. The President, His Excellency the Governor, presided.

The Archbishop of Hobart, the Most Rev. Justin Simonds, gave a lecture entitled 'The Psychology of Laughter'.

12TH MAY, 1941

A special meeting was held in the Society's Room on this date. Mr. E. E. Unwin presided in the absence of the President.

The business of the special meeting was to consider the proposal of the Council to amend Rule 67 as follows:—After the words 'Special Meeting' to add 'Notice of any proposed alteration shall be posted in the Library for not less than six days before the meeting'. It was pointed out by the Secretary that in revising the Rules in 1937 an important provision regarding the alteration of Rules had been overlooked. Old Rule 56 required that any proposed alteration to the Rules should be posted in the Library for not less than six days before the special meeting, and it was the wish of the Council that this omission should be made good. It was proposed by Mr. Meston and seconded by Dr. V. V. Hickman that the amendment to Rule 67 as stated above be accepted by the Society. This was carried without dissent.

The special meeting then concluded its business and a general monthly meeting was held.

The following were elected members of the Society:—Ordinary Members, Mr. C. C. McShane, Mr. H. O'May; Associate Members, Mr. W. B. Mather, Mr. A. Wardrop.

The Chairman exhibited a specimen of Lambs Tails (*Trichinium spathulatum*) of the Order *Amarantaceae*. This genus, which is purely Australian, is represented by 16 species in South Australia, but by only one species in Tasmania. It is found in the drier parts of the State.

The Secretary exhibited a collection of coloured copper engravings of Tasmanian scenes made by Joseph Lycett in the early part of the 19th century. Lycett, who was transported to Australia for forgery, arrived in New South Wales in 1810, and during his sojourn in Australia was responsible for a considerable amount of artistic work, including coloured drawings of New South Wales and Tasmania, which were made by him in 1819-21. In 1822 he obtained a free pardon and returned to England, and in 1824 he brought out his 'Views of Australia' in 13 parts. These consisted of 24 drawings of Tasmanian scenes and 24 of New South Wales scenes. The earlier plates were lithographed, but the later ones were engraved on copper. In 1825 the complete set was re-published in London as a single volume consisting of 48 plates, together with a map of Tasmania dated 1825 and a map of New South Wales dated 1825. The earlier plates, which had been lithographed, were re-engraved on copper, so that the complete set of the drawings in the single volume are copper engravings. It was stated that the 24 Tasmanian pictures would be exhibited in the Tasmanian Museum. They were purchased from the funds of the Friends of the Tasmanian Museum and Art Gallery.

Mr. J. W. Nicholls, F.R.C.O., A.R.C.M., then delivered a lecture on 'Some Aspects of Music', of which the following is an abstract:—

Mr. Nicholls in tracing the trends of music gave pianoforte illustrations of his lecture. Music until about the year 1200 was, he said, little more than rhythm, and was purely melodic. Counterpoint, or a collection of tunes, then developed. The mediæval centre of learning, the Church, began to develop the art of noting music, and later, with the growth of opera, the modern conception of harmony began, and its rise was helped by the increasing success of instrument makers. Contrasting the music of Bach and Handel, Mr. Nicholls said that Bach's connexion with the Church, and thus the counterpoint type of composition, determined his style. Handel was associated with opera, and wrote in a more modern manner according to the operatic characteristics of the day.

The great characteristic of the classic composers was the creation of beauty, shapeliness, and form, while the composers of the romantic age, such as Chopin, Schumann, and Wagner, wrote to express their own emotions or feelings, engendered by art and literature. The modern trend was towards the discovery of new paths in music, new outlooks, and modern composers aimed through experiment, at being different at all costs.

#### 8TH JUNE, 1941

A meeting was held in the Society's Room on this date. The President, His Excellency the Governor, presided.

The following were elected members of the Society:—Mr. C. E. Kalmberg, Mr. M. S. R. Sharland.

Dr. J. W. Evans delivered an illustrated lecture entitled 'Recent Progress in Entomology in Tasmania', of which the following is an abstract:—

The first part of the lecture was devoted to an account of investigations in the field of applied entomology, research concerned with two pests receiving special attention. These were the Light Brown Apple Moth (*Tortrix postvittana*) and Underground Grass Grubs (*Oncopera* spp.). Other insects discussed were Pasture Dung Beetles, the Lucerne Flea, the Cabbage Butterfly, and the Canary Fly and its parasite. The parasite of the Canary Fly is an egg-parasite, which was introduced into Tasmania from New Zealand in 1936. Reference was also made to the control of oak insect pests by parasites, the recent introduction of the Gorse-Seed Weevil, and an investigation that had been undertaken concerned with the food of trout.

In the second part of the lecture the value of systematic entomology was stressed and three interesting Tasmanian insects discussed. These were the primitive sucking-bug

*Hemidorsus fidelis*, which is believed to be the only living insect which has retained flaps on the first segment of the thorax that are homologous with wings; the cicada *Tettigarcta tomentosa*, with which both sexes have non-functional sound-producing organs, and the recently discovered Panorpid *Apteropanorpa tasmanica*. The last-mentioned insect is not only the first completely wingless representative of the family to be described, but the first Panorpid to be recorded from Australia. In concluding the lecturer stated that entomological research, as well as being of benefit to the community, was extremely fascinating.

#### 14TH JULY, 1941

A meeting was held in the Society's Room on this date, The President, His Excellency the Governor, presided.

Mr. Ian R. Boss-Walker was elected a member.

Dr. C. R. Brothers gave an illustrated lecture entitled 'Eugenics: The Medical Aspect', of which the following is an abstract:—

He pointed out that it is difficult to prove that mental diseases are on the increase, although recognition and committability are undoubtedly on the increase. He stated that male psychotics marry less frequently than females, and those who are mentally sick do not tend to reproduce themselves.

He gave lukewarm support to the aims of eugenics, but was of opinion that although it is doubtful if the race can be improved by eugenic methods, it would be foolish not to take all reasonable precautions in view of our ignorance of many aspects of human inheritance. He pointed out the difficulty of carrying out selective breeding in the human race, though he agreed with the principal aim of eugenics, which is to improve the human race by increasing the rate of reproduction in the superior strains and decreasing it in the inferior. He then discussed at length the methods sometimes recommended for the elimination of the unfit, namely segregation of mental defectives, contraception, prohibition of the marriage of mental defectives, sterilization of the unfit. An important section of Dr Brothers' paper was that which dealt with the genetical significance of certain human mental diseases, and he submitted valuable information of the inheritance of mental diseases which he had gathered in the course of his work at New Norfolk and other places. He pointed out, as eugenicists would be the first to concede, that our present knowledge of human genetics has not the precision which warrants the laying down of hard and fast rules for the breeding of the human species. He also criticized the methods which have been used in the investigation of the inheritance of human diseases, and in conclusion he advocated the establishment of a permanent committee to direct future researches into this question.

His lecture was illustrated by interesting pedigree charts of human mental diseases.

During the discussion on Dr. Brother's paper Dr. Pearson pointed out that biologists welcomed the information on the inheritance of human diseases which is steadily being compiled by a relatively few medical practitioners. Much of the information regarding the family history of disease obtained from patients should, however, be treated with considerable caution. His personal experience of pedigrees of human diseases, which are mostly compiled from the hearsay evidence of untrained observers, made it difficult to reconcile these pedigrees with the known facts of genetics. He recommended the establishment of a central Commonwealth body which would keep records of the medical history of every citizen of the Commonwealth. Such records would ultimately have considerable value in throwing light upon the inheritance of human diseases.

The lecture on 'The Biological Aspect' by Dr. Pearson was not given owing to insufficient time.

#### 11TH AUGUST, 1941

A meeting was held in the Society's Room on this date. The President, His Excellency the Governor, presided.

Mr. James Glennie was elected a member.

Mr. M. S. R. Sharland delivered an illustrated lecture on 'The Life of the Lyre Bird' of which the following is an abstract:—

Mr. Sharland said that, although lyrebirds had been introduced into Tasmania with the stated object of preserving them from the fox, which did not occur in this State, he did not think there was any danger of the bird ever becoming extinct in the regions to which it was indigenous, namely, the coastal parts of Victoria and New South Wales and the southern part of Queensland. This was because a popular sentiment had grown up about the bird, and was responsible for its greater protection. Publicity had brought the bird into public prominence, and it is now recognised by Australians as unique, and efforts were being made to conserve it. Nevertheless, Tasmania was glad to receive birds, and he thought they would thrive in National Park, where they had been liberated.

The lyrebird generally placed its nest on the ground, and normally laid only one egg, the incubation period of which was about six weeks. The young bird then remained in the nest for another six weeks. This meant, for nearly three months, the egg and young were exposed to attacks by ground animals, and a pair of birds was fortunate if they reared their young one successfully. This factor operated to the detriment of the bird's survival and increase.

The lyrebird preferred dense forest and nested during the winter months. It was especially notable for its mimicry and its ornamental tail.

#### 8TH SEPTEMBER, 1941

A meeting was held in the Society's Room. Mr. E. E. Unwin presided in the absence of the President.

Dr. L. A. Triebel delivered an illustrated lecture entitled 'Pasteur—A Play in Five Acts, by Sacha Guitry', of which the following is an abstract:—

At the beginning of this century the traditions of the French bourgeois drama coming from Emile Augier and the younger Dumas blended with the newer Ibsen-inspired realism of the Théâtre Libre, favouring social problem-plays like those of Brieux. The 'slice of life' obsession had reactions. Edmond Rostand revived the romantic, rhetorical drama with his eccentric but generous *Cyrano de Bergerac*, and the patriotic *Chantecler*. Maurice Maeterlinck and Paul Claudel started on a poetic, mystical and symbolist programme of lofty aim; whilst a legion of young playwrights, among them Courteline and Sacha Guitry, wrote French comedy with a new-old gusto and mastery. As playwright, theatrical manager and actor, Sacha Guitry, son of the famous actor Lucien, produced many entertaining comedies followed by a series of pageant-plays that were dramatized biographies (Debureau, Pasteur, La Fontaine, Mozart, and Béranger) most of them enlivened by the voice of his wife, Yvonne Printemps.

'Pasteur' was performed for the first time in the Théâtre du Vaudeville on the 23rd of January, 1919, and printed by Fasquelle of Paris. It was dedicated to Lucien Guitry, and the preface states that the idea of dramatizing the life of the scientist came to Sacha Guitry three years after reading the biography by M. René Valléry-Radot of his father-in-law, Louis Pasteur. In spite of difficulties this intention was fulfilled when Lucien Guitry invited Sacha to write a play especially for him. Valléry-Radot was re-read with great enthusiasm. 'For', said the younger Guitry, 'it seemed to me that I had the right to undertake a piece of work to which I felt irresistibly drawn. I have several times taken the liberty of using whole sentences as spoken by Louis Pasteur at meetings of the Academy of Medicine and elsewhere'.

Here appear both the initial impulse and the aim of Guitry: the inspiration of a great biography and the intention to honour a national scientist. The verbal indebtedness of the playwright goes beyond the italicised quotations, although in some instances he condenses, as in the Joseph Meister case (Pasteur, pp. 80-82, corresponding to Valléry-Radot, pp. 600-605). Act 2 brings the members in debate, and is based on the proceedings of the Academy. The impersonal form of the biography is here expanded and broken up into dramatic dialogue: some rôles are invented.

'Pasteur' is a series of dramatic portraits showing the scientist at five different moments of his life between the ages of 48 and 70. This breaks with the French dramatic tradition: Boileau had condemned characters ageing during the action. Moreover, there was the Aristotelian demand that the dramatic hero must not be flawless. Guitry succeeded dramaturgically by concentrating on the clash of wills between Pasteur and his opponents brought about by anger and irony in debate.

The multiplicity of dramatic characters dominated by one master figure is a conception found in Marlowe and others; but 'Pasteur', like Drinkwater's slightly earlier 'Abraham Lincoln' (1918), is essentially pageant, a series of tableaux-scenes. Australian literature has the similar 'Spinoza' (1932) by Professor Alexander Gunn. In these plays the historic events are mere agencies: 'the bearing of man facing it, is all'. Yet Guitry's task was more difficult than Drinkwater's: bacteriologists do not as yet loom as large as statesmen and generals. The pros and cons of spontaneous generation, of fermentations, microscopic control, and the infectivity of contagious diseases may be comparatively poor grist for the dramatic mill. There was a Lincoln legend; was there a Pasteur legend?

Guitry's selection of incidents from Pasteur's life was conditioned by their relation to national life: bacteriologist and patriot merged in him. The play begins effectively in 1870 with Pasteur's resolve to regain for France a leadership in scientific humanism and to turn on her the eyes of mankind for help and healing. Before the Medical Congress of all Nations at Copenhagen in 1884 he said, 'In every great scientist will be found a great patriot. The thought of adding to the greatness of his country sustains him in his long efforts, and throws him into those difficult but glorious scientific enterprises which bring about real and durable conquests'. (Vallery-Radot, p. 570.) The play ends with the presentation in the Sorbonne by the President of France of a commemorative medal on Pasteur's 70th birthday, the occasion of worldwide tributes. The final words are his 'I believe absolutely in the triumph of science and peace over ignorance and war'.

Guitry's interpretation is just to Pasteur, man and patriot, as was Lucien Guitry's acting of the rôle. Drama like this is the expression of the spirit of free inquiry, the University spirit, struggling long but victoriously against embattled forces alongside of which neither science nor literature can live. The Guitrys re-incarnated Pasteur, the soul of France, and without her the world would be alone.

The Drinkwater triumph in 'Abraham Lincoln' was the final impulse urging father and son similarly to dramatize France's greatest scientist:—

'This is the wonder always, everywhere—  
Not that vast mutability which is event,  
The pits and pinacles of change,  
But man's desire and valiance that range  
All circumstance, and come to port unspent'.

### 13TH OCTOBER, 1941

A meeting was held in the Society's Room. The President, His Excellency the Governor, presided.

Mr. W. H. Hudspeth read a paper by Miss A. L. Wayn, Government Archivist, entitled 'Sir George Arthur, Lieut.-Governor of Van Diemen's Land, 1824-1836', and maps and drawings connected with Governor Arthur were exhibited. The following is an abstract of the paper:—

George Arthur was born in 1784, the youngest son of John Arthur of 'Norley House', Plymouth. He entered the Army in 1804 as ensign in 91st Argyllshire Highlanders, was gazetted lieutenant in 1805, captain in 1808, and major in 1812. He served in Egypt, Italy, and Flanders during those years, and was wounded severely on two occasions. For distinguished gallantry at an attack on Flushing, he was thanked in General Orders and appointed Deputy Assistant Adjutant-General on the field. On his return to England he received the freedom of the City of London and was presented with a sword. Plymouth accorded him similar honours.

In 1812 George Arthur was gazetted to 7th West India Regiment stationed in Jamaica, and, on arrival there, was appointed Assistant Q.M.G. to the forces in that Colony. In 1814 he married Eliza Orde Usher-Smith, second daughter of Lt.-General Sir John Frederick Sigismund Smith, K.C.B. Seven children were born of their marriage: three of the sons joined the Army, a daughter became the wife of Sir Bartle Frere.

In 1814 George Arthur was appointed Superintendent and Commandant of British Honduras, with the local rank of Colonel, holding civil and military command, a position which he held for eight years. He received the full rank of Lt.-Colonel in 1815, and was placed on half pay in 1819. During his term of office in Honduras, a revolt of the slave

population broke out in consequence of their brutal treatment by plantation owners. This had to be suppressed for the sake of law and order, but the cruelties practised on them by their owners made Arthur an ardent abolitionist. His protests through the Colonial Office gave a strong flip to the cause among those men lead by Wilberforce, who were pleading for the abolition of slavery, though among others he earned contempt as a humanitarian. Arthur had occasion to reprimand the colonel commanding the garrison at Honduras for undue use of the lash as a punishment. Bradley disputed his authority, and was sent to England under arrest. He appealed to the War Office, and was upheld on technical grounds. On Arthur's return home at the close of his term at Honduras, Bradley brought a case of unlawful arrest against him and won his suit, the defendant being fined £100.

At the close of the case Col. Arthur was appointed Lt-Governor of Van Diemen's Land That Colony was then suffering under many disabilities, caused by its rapid expansion, the emigration of large numbers of free settlers, its dependence on New South Wales, and its need of a Supreme Court. Social and commercial problems had become acute. The British Government's policy of limiting the number of female prisoners transported was unfortunate from a moral standpoint. Male prisoners had ceased to dread the sentence of transportation; comfortable housing, regular meals, and not inordinately long working hours were an improvement on the life in London's slums, from which a large number were drawn. Their working hours, 7 a.m. to 3 p.m. in summer and 8 a.m. to 4 p.m. in the winter, were not more than the Lt-Governor's, who was frequently in his office at 7 a.m., and, when not engaged on duties outside it, attended there for the better part of the day, receiving and answering requests from citizens and settlers.

Though a strict administrator, Arthur ruled his own life and that of his household equally rigidly. It was his reputation as a stern moralist, primarily, which secured his appointment. His humanity brought him more than one reprimand, through the Colonial Office, for his petitions in favour of convicts who had shown marked good conduct, or had acted in the interests of employers when opportunity offered, thus earning in the Governor's opinion some remission on their sentence. In the case of men who had been awarded a ticket of leave and were entitled to claim a wage, he encouraged them to ask for a free passage to the Colony for their families, by which means he hoped to ameliorate the lot of the prisoners and improve the moral life of the island, at least among that class. Governor Arthur decided that life at the penal settlement of Macquarie Harbour was too severe. He opened one at Maria Island in 1825, a place of lighter punishments, and limited the sentence to Macquarie Harbour to three years. However, the Home Government complained of the additional expenditure incurred. This caused his decision to close both and take over the sawmilling station near Stewart's Harbour as an ultra-penal settlement in 1833. Employment at Macquarie Harbour had been chiefly timber-milling and ship-building. These were continued at the new settlement (to be known as Port Arthur), with the addition of coal mining, which developed further under succeeding Governors. The change to more genial surroundings was shown in the marked improvement in the conduct of the prisoners. Numbers were brought back after short intervals to the settled districts for lighter service.

Under his commission of Lt-Governor, Arthur was directed to protect the native population. His natural kindness of heart made him anxious to further their interest in any case, but the position was difficult. Constant complaints were sent in by settlers of the theft of their sheep and cattle and the death of their stockmen from frequent native raids. Revenge taken by the owners led to more hostilities, until the Governor was forced, in 1828, to proclaim martial law. On its failure, the 'Black Line' was carried out a year later in the hope that many natives would be captured and segregation of their race could be carried out systematically. The Line, which was formed by a chain of temporary small camps across the Colony, manned by Military and settlers, proved a dire failure and a heavy expense to the Home Government. Eventually the offer of a builder named George A. Robinson was accepted to attempt the capture of small parties. He had previously won the friendship of those whom curiosity and the encouragement of the Governor and residents had brought into Hobart Town from time to time, and was hopeful of success. Accompanied by two or three natives, he was able to persuade others to come in with him in the next few years. In 1832 segregation was begun at Flinders Island and Robinson was appointed Superintendent of the Settlement, with a catechist, a doctor, and a small party of Military. Though it proved a failure in later years, it is recorded that the arrangements laid down by Col. Arthur showed excellent judgment and sympathy with their needs.

Bushranging was rife in the Colony before and after his administration began. His measures improved matters for short periods, but a large military force was necessitated to keep down their increase in the Colony for many years.

Van Diemen's Land received a separate constitution and independence from New South Wales in December of 1825. Governor Arthur laid down the civil departments and published

a clear statement of the work to be carried out by each. He enlarged the personnel of the Executive and Legislative Councils, inaugurated the Bench of Magistrates, appointed a Colonial Secretary (formerly known as governor's secretary), a Treasurer, and Auditor, and instituted Trial by Jury. A Supreme Court had been established in 1824, the year of his appointment. Prior to 1827 an official known as 'Naval Officer' collected the entire revenues. After the appointment of a Treasurer, his duty was confined to harbour and post collections. In 1829 His Majesty's Customs Department established a branch in the Colony.

The need of churches and schools in Van Diemen's Land was serious in the 'twenties'. The Home Government consented to the erection of six of the former and the establishment of district schools in settled districts, under masters, some of whom were catechists also, and four or five chaplains were sent out to serve the churches built and under erection.

The Survey Department was insufficiently staffed to cope with the amount of field work entailed by the increasing number of free grants to incoming settlers during those years. Boundaries were not clearly pegged out, and in many instances grantees built and cultivated lands inside their neighbours' acreage. Restitution and readjustment entailed expense to the Government. The Governor was blamed by the settlers, though the trouble began before his arrival; while the Home Government resented the expenditure.

Colonel Arthur received his recall after 12 years of administration. He carried with him from Van Diemen's Land numerous Addresses expressing appreciation of his reforms and of the Colony's marvellous advance in prosperity during his term of office.

On arrival in England Colonel Arthur received the honour of knighthood, and was appointed Governor of Upper Canada. Trouble occurred in 1838 between the two provinces, and rebellion broke out. The British Government decided to merge Upper and Lower into one province. Sir George disagreed with that policy, and asked to be allowed to return to England. His resignation was accepted. The Canadian Press eulogized his statesmanship and manly qualities.

After his arrival in England the Queen forwarded him her gracious approbation of his services, and created him a Baronet. In 1842, a year after his return, he was appointed Governor of Bombay.

During his service in India, the Press of that country invariably praised his administrative qualities. Its testimony was endorsed by Sir Henry Hardinge, the Governor-General, when on the threat of an outbreak of war he advised the British Government, in the event of his having to take to the field, to appoint Sir George Arthur to his own office. The Government agreed to his suggestion, but the proposed honour came at a time when the administration of his province was almost beyond Arthur's physical strength. The long years of strain had taken their toll, his health grew worse in 1846, and he asked to be allowed to resign. The change back to his native climate brought improvement.

In the following year he was made a member of the Privy Council, and received the Honorary Degree of D.C.L. of Oxford. In 1853 Sir George was gazetted Colonel of the 50th Regiment, and in 1854 was promoted Lieut.-General. During that year he was attacked by a severe illness. His death occurred on 19th September at his home in Gloucester Square, Hyde Park, London, in his 71st year.

Though Sir George received the approbation of his Sovereign and was eulogized by the current press of the other countries in which he held office, modern writers have continued to allow the malignity expressed by the ex-convict editors of Van Diemen's Land to mar the name and memory of a man who has since been entitled 'One of the British Government's greatest Pro-consuls'.

The following papers were laid on the table and taken as read:—

- (1) A Tasmanian Stone Implement made from bottle glass. By N. B. Tindale.
- (2) Some Tasmanian Palaeozoic Corals. By Dorothy Hill.
- (3) The Grapsid and Ocypodid Crabs of Tasmania. By M. W. F. Tweedie.
- (4) New Leaf-Hoppers from Tasmania and Queensland. By J. W. Evans.
- (5) A Mecopteran Larva from Tasmania, and Notes on the Morphology of the Insect Head. By J. W. Evans.
- (6) The Nitrogen Bases in Tasmanite Shale Oil. By R. F. Cane.

10TH NOVEMBER, 1941

A meeting was held in the Society's Room on this date. Mr. Henry Allport presided in the absence of the President.

Mr. H. G. Vaughan was elected a member.

The following papers were laid on the table and taken as read:—

- (1) A New Ichthyobdellid Leech and Its Egg-Capsules. By V. V. Hickman.
- (2) Observations on Some Tasmanian Fishes: Part V. By E. O. G. Scott.
- (3) The Phylogeny of the Homoptera. By J. W. Evans.

Mr. L. R. S. Benjamin delivered an illustrated lecture entitled 'Some Aspects of the Development of the Eucalyptus Pulping Industry and the Manufacture of Newsprint', of which the following is an abstract:—

The lecturer pointed out that conifers have been the source of supply of wood pulp for the paper industry for nearly three generations. The feasibility of using eucalypts for the manufacture of newsprint was considered very doubtful twenty-five years ago, and it is since that time that a process has been evolved by which the Tasmanian hardwoods can be utilized successfully in the manufacture of paper pulp.

Mr. Benjamin first explained at some length the structure of natural wood, and pointed out that the fibres constitute the 'units' of pulp. Conifers are more easily adapted for the making of pulp than eucalypts, as the fibres of the former are very much longer than those of the latter, and it was for this reason that H. E. Surface in 1916 stated that eucalypts were entirely unsuitable for making pulp. The weight of opinion at that time was strongly against the feasibility of using short-fibred wood pulp from eucalypts for any purpose other than as a filler to produce bulk and opacity in certain types of paper. The first aim of the paper manufacturer is to reduce the wood to its constituent fibres. The structural elements of wood are essentially cellulose, which is insoluble and not readily digestible. The separation of the cellulose fibres can be done by chemical as well as mechanical means. The essential principle of paper-making is the suspension of these macerated fibres in water and then straining them on a sieve. If the sieve takes the form of an endless belt a continual sheet of paper is produced.

The lecturer then described the various processes by which wood is converted into pulp, including the mechanical or grinding process and the chemical process, and he pointed out that at Boyer the grinding process is used. The pulp then undergoes a treatment known as beating. This is a mechanical process which develops the colloidal properties of the cellulose fibres. Different types of papers can be produced by a longer or shorter beating. In the case of newsprint, beating does not play an important part, as the principal ingredient is ground wood pulp, which no amount of beating will improve.

Mr. Benjamin then outlined the progress and sequence of experiments which have been made in the last twenty-five years in order to find some method of utilizing eucalypts in the paper-making industry. In their early experiments it was found that the percentage of cellulose was quite as high as in the soft woods and that pulp of high strength could be made from eucalypts by the proper combination of cooking factors. When the process had been established and success was assured, the Derwent Valley was recommended as the seat of the newsprint industry because here alone sufficient quantities of *Eucalyptus regnans* exist to supply the needs of an industry which must operate at least 400 tons of paper daily. Eucalyptus newsprint, therefore, may be regarded as a symbol of what can be achieved by the application of scientific methods to industrial problems.

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## Northern Branch

### Annual Report, 1941

Meetings of the 1941 Session, other than the Annual Meeting and Public Lecture and the September Meeting, were held in the Lecture Room at the Queen Victoria Museum and Art Gallery.

26TH MAY, 1941

#### *Annual Report and Public Lecture*

The Annual Meeting for 1941 was held in the class-room, Public Library, at 7.30 p.m.

Mr. F. Smithies presided. The following were elected officers for 1941:—

President: Mr. F. Smithies.

Council: Mr. F. Smithies (Chairman), Mr. F. Heyward, Hon. Tasman Shields, Mr. W. R. Rolph, Mr. G. McKinlay, Mr. J. R. Forward, Mr. D. V. Allen, Mr. J. E. Heritage, Dr. R. A. Scott.

Hon. Secretary: Mr. E. O. G. Scott.

Hon. Auditor: Mr. J. R. Forward.

The Annual Report and the Statement of Accounts, which showed a credit balance of £35 17s. 3d., were read and adopted.

The Annual Meeting was followed, at 8 p.m., by a public lecture, 'Frenchman's Cap' by the Branch President, Mr. F. Smithies. The lecture was given in the Public Library Hall; there was an attendance of upwards of two hundred and fifty.

Mr. Smithies traced the history of the Frenchman's Cap (origin of name unknown; possibly bestowed by one of the French explorers in passing along the coast in 1870), with reference to Surveyor W. S. Sharland, 1832 (Sharland, extracts from whose diary were read, confused the Derwent, and thought that Lake St. Clair, which he saw from Mount Charles, and named Gordon Lake, was the source of the Gordon River); James Sprent, about 1850 (reached the summit, and erected a trigonometrical cairn), Tulley, Glover, and Spon, 10th January, 1857; T. B. Moore, 1888 (first ascent from western side); F. E. Philp, 1910 (made track to mountain, but did not climb it); track cut from Crotty in 1913 used by several parties from Queenstown under the guidance of the late Charles Whitham (this track remained open for only three years and was disused after 1916); F. Smithies and C. Bradshaw, 1932; A. I. Davern, 1933.

The second section of Mr. Smithies' lecture took the form of the projection of a number of lantern slides and of a moving picture in full natural colour showing various stages of a recent ascent of the mountain by himself, Mr. R. Hall, and Mr. P. H. Bond.

23RD JUNE, 1941

The President, Mr. F. Smithies, presided.

Mr. R. Boswell gave an illustrated lecture on 'Modern Museum Display Methods'.

Mr. Boswell's address fell into three sections—first, a general account of the speaker's recent visit to U.S.A., under the auspices of the Carnegie Corporation of New York, to attend a course of instruction in taxidermy and museum preparation, conducted by Mr. Frank Tose, Chief of Exhibits, California Academy of Sciences, San Francisco; secondly, a survey of some modern techniques (with special reference to latex preparations); thirdly, an account of the various stages in the mounting of a mammal.

In dealing with some modern developments in museum preparation, the speaker supplied some very interesting information on methods of moulding and casting in latex, a very adaptable, and now widely used, medium: Latex preparations of reptiles and amphibians

were handed around for inspection. Mr. Boswell then traced in detail the various steps in the mounting of a gnu, the successive stages involved being illustrated by photographs projected by an epidiascope.

The lecture was followed by a discussion, to which nearly all the members present contributed.

#### 28TH JULY, 1941

The President, Mr. F. Smithies, presided.

Mr. J. B. Boag gave a lecture on 'Textile Dyeing'.

Mr. Boag, Research Chemist, Paton's and Baldwin's Mills, introduced his subject by a brief historical survey of dyeing from the early times, and laid down a fundamental distinction between household dyeing and dyeing by processes on a commercial scale. He then proceeded to make a systematic survey of six main groups of dyes, of the methods of using them, and of their reactions on vegetable and animal fibres. The principles of mordanting were discussed, and interesting references were made to practical problems encountered in commercial dyeing.

Mr. Boag then proceeded to trace in detail the whole process of dyeing a fabric, such as a suiting. Fairly full consideration was given to various aspects of colour-matching, fastness of dyes to light and water, and production of non-shrink fabrics, the successful approaches of modern research to these problems being demonstrated by the display of an extensive series of samples.

The lecture was followed by a discussion, in which virtually all members present participated.

#### 25TH AUGUST, 1941

The President, Mr. F. Smithies, presided.

Mr. M. S. R. Sharland gave a lecture on 'The Life of the Lyre Bird'.

#### 29TH SEPTEMBER, 1941

The President, Mr. F. Smithies, presided.

The September meeting was held in the Main Hall, Public Library.

The Hon. the Minister for Lands and Works, Hon. T. H. Davies, presided.

Mr. F. W. Hicks, Superintendent of Agriculture introduced Mr. C. L. Goldstone, B.Sc.Ag., who gave a lecture on 'The Menace of Soil Erosion'.

Mr. Goldstone, who has been engaged for some time in making a survey of the problem of soil erosion in Tasmania, gave a general address on soil erosion, followed by an account of the results of some of his own investigations. In dealing with local examples, the lecturer first discussed the plight of many orchards in the West Tamar district and in southern Tasmania: pictures taken in these localities showed trees with exposed roots, the result of wind or water action. It was pointed out that the honeycombing of land by rabbits frequently gives rise to a state of conditions conducive to extensive erosion by winds. A striking example of water erosion cited is one in which, in one property investigated by Mr. Goldstone, a great gully, by formation of which 15,000 cubic yards of soil had been lost, has been produced by water deepening a plough-line made to drain a paddock. The destruction of land in coastal areas by encroaching sand was also described, typical examples being illustrated by means of lantern slides.

At the conclusion of Mr. Goldstone's lecture, a sound-film, 'The Menace of Erosion' was shown: the film, prepared by the Rural Bank of New South Wales, was screened by courtesy of the Bank.

27TH NOVEMBER, 1941

The President, Mr. F. Smithies, presided.

Mr. E. O. G. Scott gave a lecture on 'A Naturalist in Tasmania'.

After some introductory observations on the scope and complexity of present-day biological research, Mr. Scott pointed out the exceptionally favourable opportunities that exist in Tasmania for work both by the specialist and the field naturalist. General consideration was then given to the geographical and biological characteristics of Tasmania in relation to those of the mainland of Australia, New Zealand, and South America. The striking similarity of the fauna of the regions delimited by Bass Strait was discussed, and it was pointed out that, in many respects, the fauna of the northern half of the State is more closely assimilated to that of Victoria than to that of the southern part of the Island.

The geological history of the State was traced in broad outline to present a general picture of the involved course of events from pre-Cambrian times onward; and some fossils characteristic of the various periods were considered. Some general remarks were made on the interest to the naturalist of our local mammals; and, in conclusion, a brief account was given of some of Tasmania's so-called living fossils.

The lecture was followed by a discussion, in which most of the members participated.

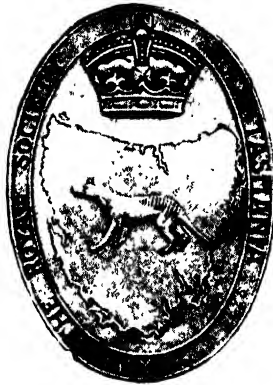
#### COUNCIL MEETINGS

Council Meetings were held on the 5th May, 9th June, 3rd July, 11th August, 8th September, 14th October, and 1st December.

PAPERS AND PROCEEDINGS  
OF  
THE ROYAL SOCIETY  
OF TASMANIA

FOR THE YEAR

1942



Edited by

JOSEPH PEARSON

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PUBLISHED BY THE SOCIETY

The Tasmanian Museum and Art Gallery, Hobart

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1943

*Price: Ten Shillings*



# The Royal Society of Tasmania

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## Papers and Proceedings, 1942

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## The Phreatoicoidea

By

G. E. NICHOLLS

*Professor of Biology, University of Western Australia*

(Read 24th August, 1942)

### PART I.—The AMPHISOPIDAE

#### PREFACE

The accumulation of material for a survey of this sub-order was begun as far back as 1925 and a short first instalment was published in the following year. A few months later, however, there appeared a 'Revision of the Phreatoicidae' by Miss Sheppard, but with many of the opinions expressed in that work, and particularly with the systematic grouping proposed, the present writer found himself in marked disagreement.

It was realized, however, that the subject could be dealt with adequately only by a re-examination of a large number of examples of all known species. During the fifteen years which have elapsed since Miss Sheppard's paper appeared, some thousands of specimens have been examined.

Among these were numerous examples kindly loaned by the Directors of the Australian Museum, Sydney, and of the National Museum, Melbourne, as well as the entire collection of Phreatoicids from the Museums at Adelaide and Hobart. This last collection includes specimens obtained in connexion with the Tasmanian Biological Survey and is enormously swollen by the material secured by Mr. J. W. Evans in connexion with his valuable 'Fish Food Investigations'. A debt of gratitude is owing to Professor Wadham of the University of Melbourne, who made several special trips to the Otways Mts. in search of living *Phreatoicopsis*, while Dr. K. Barnard of the South African Museum, Capetown, made a generous contribution of specimens from that region. The late Professor Chilton kindly sent examples of known New Zealand species, while co-types of Geoffrey Smith's Tasmanian forms were given by Professor Bourne. Still more material has been brought together by personal collection in Victoria, Tasmania, New Zealand, and Western Australia, some of these collecting trips being made possible by generous grants from the Trustees of the Australian Science and Industry Endowment Fund, to whom grateful acknowledgment is due.

Thus, the completed paper has grown to such proportions that it has now been found necessary to divide it into two parts for publication. The present part (Part I) deals with the Amphisopidae; Part II, which it is proposed to publish in the 1943 volume of this Journal, will deal with the Phreatoicidae. It is



unavoidable that certain new genera and species, which will be fully described in Part II, are referred to by name in the present part. Such new names will, of course, have no validity until their full description has been published. It should be added that the cost of printing the paper is being met in part by contributions from the funds of the Tasmanian Biological Survey and of the University of Western Australia, to the authorities of both of which bodies my thanks are tendered. Finally, I am indebted to Dr. Pearson for helpful advice and suggestions concerning the form the paper should take.

## INTRODUCTION

Since the appearance in 1894 of the first detailed description of a Phreatoicid (*Phreatoicus australis*, Chilton), many additional members of this group have been described, the authors having, in most cases, been content with a description of the new form in terms of comparison with *australis*. This fashion of description has the sole recommendation that it makes for brevity, but, unless it be accompanied by detailed figures, can be most misleading. For, unlike the Amphipods of which Stebbing remarked (1888, p. 475), that while from their descriptions they might seem to be practically identical, yet when placed 'side by side, it is rather the differences of the facies than the likeness which attracts attention', of the Phreatoicids the reverse is the case. The general external likeness throughout the whole group (excepting subterranean forms) is very marked indeed, and it is only a close scrutiny that reveals the range of structural difference.

Phrases such as 'in general very like *P. australis*', 'like *P. australis* except . . .' and 'as in *P. australis*' constantly recur, being used frequently without sufficient justification.<sup>(1)</sup> As a consequence, it has come about that a sentence in Chilton's original account of *P. latipes* 'does not differ very much from *P. australis*' can become transmuted in the work of another author (Sheppard) into 'very similar to those of *australis*', although, in fact, the two types present the most markedly dissimilar facies and are, indeed, to be ranked in different families.

It has happened, therefore, in some cases, that such brevity of description has resulted in a misrepresentation of the new species, having tended to minimize the significance of characters actually quite distinctive, and often of considerable taxonomic importance. To the reader, there is conveyed the impression that, while there undoubtedly exist, in the form under discussion, differences from *australis*, these modifications are, nevertheless, trivial, and, at most, of specific importance.

Moreover, reliance upon this inexact method of description (failing, as it so often has done, to provide the facts required later for critical comparison) has also been responsible, in some cases, for the lack of sufficiently careful and complete investigation. It has served, too, to foster the quite erroneous idea that *P. australis* is the most generalized of the extant forms and, indeed, closely like the Triassic Phreatoicid from which extant forms might presumably have been derived. This misconception explains the failure to appreciate the existence of two well-marked groups within the sub-order.

The matter is one of considerable importance, for upon its correct understanding depends our recognition not only of the position of the Phreatoicoidea within the Isopoda but also of their relationship to other Peracaridan orders, including the Amphipoda. Barnard (1927), in a valuable contribution to this

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<sup>(1)</sup> The writer admits that he, too, has relied more than once upon this loose and frequently inaccurate method of description.

subject, discusses the evolutionary tendencies within this group, but, influenced by his belief in the 'likeness' of *P. capensis* to *P. australis*,<sup>(1)</sup> accepts as an established fact the primitive character of the *australis* facies. He endorses Chilton's view of the 'very close relationship to the Asellidae' and agrees that 'the resemblances to the Amphipoda, though interesting, have been exaggerated' (1927, p. 213).

For the alternative view that *P. australis* and its group of nearly related species, mostly sub-alpine, may be modified and stunted forms derived from an older (Amphisopine) type of more robust lowland species, a clear case can be made out.

This suggestion was first made by the writer in 1926, in a paper of which only a summary was published (1928). Since then, all but one of the known species and many others, new, have been examined and have provided evidence supporting the view that the Amphisopine type is phyletically the older. From this viewpoint the closest relationship within the Isopoda would appear to be with the Cirolanidae rather than with the Asellota. To non-Isopodan groups, the Amphisopidae seem nearest akin to the Apseudidae, and since these latter are presumably representative of a more primitive stock of Peracarida, with possible relationship to Amphipoda, the resemblances of the Phreatoicids to the Amphipodan type may be indicative of parallelism in evolution in forms derived from a common stock rather than, as Chilton has maintained, merely a superficial resemblance due to convergent evolution.

The sub-order appears to be an extremely ancient one which, quite early in the Mesozoic, had probably established a fairly stable 'Amphisopine facies'. Further, the divergence of the extant forms from this common stock almost certainly began very long ago, so that many of the existing species, superficially so alike, actually represent widely-separated end branches and should rank as monotypic genera. Several have taken, independently, to subterranean life and there has resulted a new, convergent resemblance in forms that were probably comparatively widely separated phyletically. Thus the attempt to establish an orderly classification of the genera of this sub-order proves a very perplexing business. A number of significant characters have come to light, which can only be interpreted as instances of the retention of more primitive Peracaridan features, and, therefore, their absence or modification attributable to complete or partial suppression. In the extant members of this group, such diverse combinations of presence and absence of these distinctive characters are met with that it becomes a real problem to decide which species is to be regarded as, on the whole, the most primitive, and to attempt to align the remaining forms in correct relation to this and to each other.

The length of this account of the Phreatoicoidea has made it necessary to publish in two parts. Accordingly, it has seemed desirable to include in Part I the list of literature to which reference is made and which would normally come at the end of the paper. It is most conveniently inserted here.

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(<sup>1</sup>) It may be noted that Barnard's comparison of *capensis* with *australis* (1927, pp. 158, *et. seq.*) is based on examination of specimens from Tasmania (Mt. Wellington) which are not actually *australis*, although undoubtedly nearly related to that species.

## REFERENCES

- BARNARD, K. H., 1913.—'Phreatoicus in South Africa', *Nature*, vol. 91, p. 372.  
 —, 1914.—'Description of a new Species of Phreatoicus (Isopoda) from South Africa', *Ann. S. Afr. Mus.*, vol. 10, pp. 231-240.  
 —, 1924.—'The Digestive Canal of Isopod Crustaceans', *Tr. Roy. Soc. S. Afr.*, vol. 12, pp. 27-36.  
 —, 1927.—'A Study of the Freshwater Isopodan and Amphipodan Crustacea of South Africa', *Tr. Roy. Soc. S. Afr.*, vol. 14, pp. 139-215.
- BORRODAILE, L. A., 1926.—'Notes upon Crustacean Limbs', *Ann. Mag. Nat. Hist.* (9), vol. 17, pp. 193-213.
- BOUVIER, E. L., and EDWARDS, A. MILNE, 1902.—'Les Bathynomes', *Mem. Mus. Comp. Zool. Harv.*, vol. 27, pp. 141-175.
- CALMAN, W. T., 1909.—*Treatise on Zoology . . . Crustacea*, London.  
 —, 1911(1).—'On Pleurocaris, a new Crustacean from the English Coal Measures', *Geol. Mag.*, Dec. 5, vol. 8, pp. 156-160.  
 —, 1911(2).—'On some Crustacea of the Division Syncarida from the English Coal Measures. II. Further notes on Pleurocaris annulatus', *Geol. Mag.*, Dec. 5, vol. 8, pp. 494-5.  
 —, 1918.—'A Triassic Isopod Crustacean from Australia', *Geol. Mag.*, Dec. 6, vol. 5, pp. 277-280.
- CANNON, H. G., and MANTON, S. M., 1927.—'On the feeding mechanism of a Mysid Crustacean Hemimysis lamornae', *Trans. Roy. Soc. Edin.*, vol. 55, pp. 219-253.  
 —, 1929.—'On the feeding mechanism of the Syncarid Crustacea', *Trans. Roy. Soc. Edin.*, vol. 56, pp. 175-189.
- CHILTON, CHAS., 1882.—'Notes on, and a new Species of, Subterranean Crustacea', *Tr. N.Z. Inst.*, vol. 15, pp. 87-92.  
 —, 1884.—'Subterranean Crustacea', *N.Z. Jrn. Sc.*, vol. 2, p. 89.  
 —, 1891.—'On a new and peculiar Freshwater Isopod from Mt. Kosciusko', *Rec. Austr. Mus.*, vol. 1, pp. 149-171.  
 —, 1894.—'The Subterranean Crustacea of New Zealand; with some general remarks on the Fauna of Caves and Wells', *Tr. Linn. Soc. Lond.*, vol. 6, pp. 163-284.  
 —, 1905.—'Description of a Species of Phreatoicus from the Surface Waters of New Zealand', *Tr. N.Z. Inst.*, vol. 38, pp. 273-275.  
 —, 1916.—'Some Amphipoda and Isopoda from Barrington Tops (4600 ft. alt.), N.S.W.', *Pr. Roy. Soc. N.S.W.*, vol. 50, pp. 82-98.  
 —, 1917.—'A Fossil Isopod belonging to the Freshwater Genus Phreatoicus', *Pr. Roy. Soc. N.S.W.*, vol. 51, pp. 365-388.  
 —, 1922.—'A new Isopod from Central Australia belonging to the Phreatoicidae', *Tr. Roy. Soc. S. Aust.*, vol. 46, pp. 23-33.  
 —, 1924.—*The Chrietchurch Artesian and the City Water Supply*, pp. 7-10.
- DENNELL, R., 1934.—'The feeding mechanism of the Cumacean Crustacean, Diastylis bradyi', *Trans. Roy. Soc. Edin.*, vol. 58, pp. 125-141.  
 —, 1937.—'On the feeding mechanism of Apseudes talpa and the evolution of the Peracaridan feeding mechanism', *Trans. Roy. Soc. Edin.*, vol. 59, pp. 57-78.
- GLAUERT, L., 1924.—'A Freshwater Isopod Phreatoicus palustris, n.sp.', *Journ. Roy. Soc. W.A.*, vol. 10, pp. 49-57.
- HANSEN, H. J., 1893.—'A Contribution to the Morphology of the Limbs and Mouth-parts of Crustaceans and Insects', *Ann. Mag. Nat. Hist.* (6), vol. 12, pp. 417-434.  
 —, 1903.—'The deep-sea Isopod Anuropus branchiatus Beddard, and some remarks on Bathynomus giganteus, A. Milne Edwards', *Journ. Linn. Soc. Lond.*, vol. 29, pp. 12-25.
- HEWITT, C. G., 1907.—'Ligia', *L.M.B.C. Memoirs*, No. 14.
- MANTON, S. M., 1928.—'On some points in the anatomy and habits of the Lophogastrid Crustacea', *Trans. Roy. Soc. Edin.*, vol. 56, pp. 103-119.
- NICHOLLS, G. E., and MILNER, D. F., 1923.—'A new genus of Freshwater Isopoda, allied to Phreatoicus', *Journ. Roy. Soc. W.A.*, vol. 10, pp. 23-34.
- NICHOLLS, G. E., 1924.—'Phreatoicus lintoni, a new species of freshwater Isopod from South-Western Australia', *Journ. Roy. Soc. W.A.*, vol. 10, pp. 91-104.  
 —, 1926.—'A Description of Two New Genera and Species of Phreatoicidea, with a Discussion of the Affinities of the Members of this Family', *Journ. Roy. Soc. W.A.*, vol. 12, pp. 179-210.  
 —, 1928.—'The Distribution and Affinities of the Phreatoicidea', *Proc. Third Pan-Pacific Sc. Congress*, 1926, pp. 2286-2287.  
 —, 1929.—'Notes on Freshwater Crustacea of Australia', *Vict. Nat.*, vol. 45, pp. 285-295.
- NORMAN & STEBBING, 1886.—'On the Crustacea Isopoda of the "Lightning", "Porcupine", and "Valorous" Expeditions', *Trans. Zool. Soc.*, vol. 12, part 4, pp. 77-141.

- PACKARD, A. S., 1886.—'On the Syncarida, a hitherto undescribed synthetic group of extinct Malacostracous Crustacea', *Mem. Nat. Acad. Sci.*, vol. 3, Mem. 15, pp. 123-128.
- RAFF, J. W., 1912.—'Notes on the Isopod *Phreatoicopsus terricola*, Sp. and Hall', *Vict. Nat.*, vol. 29, pp. 70-71.
- RICHARDSON, H., 1905.—'Monograph on the Isopoda of N. America', *Bull. U.S. Nat. Mus.*, No. 54, pp. liii, 727.
- SARS, G. O., 1867.—'Histoire Naturelle des Crustacés d'eau douce de Norvège, 1867.
- , 1885 (1).—'Report on the Schizopoda collected by H.M.S. 'Challenger', vol. 13, part 37.
- , 1885 (2).—'Den Norske Nordhavs Expedition, Zool. Crustacea I.
- SAYCE, O. A., 1900 (1).—'Phreatoicoides, a New Genus of Freshwater Isopoda', *Proc. Roy. Soc. Vict.*, vol. 12 (n.s.), pp. 122-138.
- , 1900 (2).—'Phreatoicus shephardi, a New Species of Freshwater Isopoda from Victoria', *Proc. Roy. Soc. Vict.*, vol. 13 (n.s.), pp. 25-28.
- , 1901.—'On three Blind Victorian Freshwater Crustacea found in Surface Water', *Ann. Mag. Nat. Hist.* (7), vol. 8, p. 558.
- , 1902.—'A new Genus of Phreatoicidae', *Proc. Roy. Soc. Vict.*, vol. 14 (n.s.), pp. 218-224.
- SHEARD, K., 1936.—'A new Phreatoicid from the Grampians, Victoria', *Rec. S. Aust. Mus.*, vol. 5, pp. 469-473.
- SHEPARD, E. M., 1927.—'Revision of the Family Phreatoicidae (Crustacea), with a description of two New Species', *Proc. Zool. Soc. London*, 1927, pt. 1, pp. 81-124.
- SMITH, G. W., 1909.—'The Freshwater Crustacea of Tasmania, with Remarks on their Geographical Distribution', *Tr. Linn. Soc. Lond.*, vol. 2, pp. 61-92.
- SPENCER, B., and HALL, T. S., 1896.—'Description of a New Genus of Terrestrial Isopoda allied to the Genus *Phreatoicus*', *Proc. Roy. Soc. Vict.*, vol. 9 (n.s.), pp. 12-21.
- STEBBING, T. R. R., 1888.—'Rept. on Amphipoda collected by H.M.S. 'Challenger', vol. 29, p. 543 and p. 687.
- , 1893.—*Hist. of Crustacea*, Lond.
- THOMSON, G. M., and CHILTON, CHAS., 1886.—'Critical List of the Crustacea Malacostraca of New Zealand, Part I.', *Trans. N.Z. Inst.*, vol. 18, p. 151.
- THOMSON, G. M., 1893.—Postscriptum to 'Notes on Tasmanian Crustacea, etc.', *Pap. Roy. Soc. Tasmania*, 1892 (1893), p. 76.
- , 1894.—'On a New Species of *Phreatoicus* from Tasmania', *Ann. Mag. Nat. Hist.* (6), vol. 13, pp. 349-351.
- WHITE, H. L., 1917.—'North Australian Birds', *Emu*, vol. 16, pp. 117-158.

EXPLANATION OF LETTERS, ETC., USED ON FIGURES<sup>(1)</sup>

- |                            |                 |                        |
|----------------------------|-----------------|------------------------|
| 1. Entire animal.          | 6. Mandible.    | 11. Gnathopod.         |
| 2. Head, enlarged.         | 7. Labium.      | 12. Peraeopod (2)-(7). |
| 3. Tailpiece.              | 8. Maxillula.   | 13. Pleopod (1)-(5).   |
| 4. Antennule and Antenna.  | 9. Maxilla.     | 14. Penial stylet.     |
| 5. Labrum (with Epistome). | 10. Maxilliped. | 15. Uropod.            |

*a.* anterior view; *ac.* acetabular process; *a.m.* antero-mesial view; *ap.* apodeme; *a.s.* anterior row of setae; *b.* basis; *c.* coxa, coxal lobe; *d.* dorsal view; *e.* external view; *en.* endopodite (palp); *ep.* epistome; *ex.* exopodite; *f.* fulcral process; *fil.* row of filtratory setae; *h.* hand; *hl.* hinge line; *l.* left; *l', l'*, endites of first and third segment of maxilla; *la.* labrum; *m.* mesial view; *ma.* opening for adductor muscle; *md.* mandible; *mo.* molar; *mp.* median process; *ms.* mesial surface of maxilla; *o.* oostegite; *p.* posterior; *pa.* paragnaths; *pct.* pectinate setae; *pl.* (1)-(6). pleura of pleon segments; *pm.* petasma?; *p.mr.* margin, enlarged, of basis of peraeopod; *pp.* palp; *pr.* posterior row of setae; *pr.v.* peraeon in ventral view; *p.t.* pleo-telsonic suture; *r.* right; *s.* lateral; *sp.* spine row; *st.* sternum; *t.s.p.* transverse section through peraeon segment; *t.s.pl.* transverse section through pleon segment; *v.* ventral.

(<sup>1</sup>) Lines are placed alongside some of the drawings, particularly of drawings of the entire animal. These lines represent a length of 1 mm.

## A BASIS FOR CLASSIFICATION.

In order to avoid much repetition, it is proposed to discuss, at this stage, some of the more important characters of diagnostic value; they are:—(a) those which relate to the head—the rostrum, eyes, antennule, antenna, mouth parts and cervical groove; (b) in the peraeon—the presence of ridges on the segments, the relation of the first peraeon (i.e., second thoracic) segment to the head, that of the coxae of the peraeopods to their segments, the expansion of the bases and other joints in the peraeopoda, the arrangement and number of the oostegites and the occurrence of median sternal processes; (c) in the pleon—the characters of pleopods, uropods, and tailpiece; and (d) the condition of the typhlosole.

## 1. Rostrum

In the Peracarida, a rostrum is fairly generally developed. It has, however, largely vanished in the Isopoda (although still present in some Asellote forms). It is of interest, therefore, that in a few Phreatoicoidea there is found, clearly defined and separating the antennules upon the anterior surface of the head, a ridge elongated vertically which suggests a vestigial condition of this structure.

## 2. Eyes

On the balance of evidence, it seems probably that the ancestral form had eyes, large and well-developed, which have undergone reduction independently and at different times, in members of genera of both divisions of this sub-order, as these abandoned active life in surface waters for a creeping cryptozoic or subterranean mode of life. In the Amphisopidae, the eyes are typically very prominent and large, with many ocelli; they may be smaller but still well developed and prominent (*Mesamphisopus*, *Uramphisopus*), or they may have come near to disappearance or be wholly absent (*Hyperoedesisopus*, *Hypsimitopus*, and *Phreatoicoidea*). In the Phreatoicidae, well-developed prominent eyes persist but rarely (*Mesacanthotelson*) and, in most, the eyes are undergoing reduction, are variably small or wanting (*Metaphreatoicus*), or have gone without trace (*Phreatoicus* and *Notamphisopus*).

## 3. Antennules

A multi-jointed filiform condition of the antennule is, also, one which from its wide occurrence in Malacostraca might reasonably be expected to prove a primitive character. In the Peracarida the multi-articulate condition of this appendage persists in Mysidacea, many Amphipoda and in the Apsedidae. It occurs, also, in widely separate sub-orders of the Isopoda, but on the whole, in this latter group, the antennule is short or very short. But in all Phreatoicids (even in those in which a many-jointed flagellum is found in adult life), the young (where known) emerge from the brood-pouch possessed of a short, club-shaped antennule with few joints. It would be arguable, therefore, that in this sub-order such a multi-articulate condition of this appendage is an independent reacquisition due to adaptation to more active (or more exposed) mode of life and *not* the retention of a primitive character. Against this view is to be set the fact that a many-jointed condition in the adult occurs only in species in which it is linked with a preponderance of other, undoubtedly primitive, characters. Thus it is highly probable that it should be included in the category of primitive characters and that the short, club-shaped antennule of sub-alpine Australian

genera is correctly to be interpreted as a stunted condition, the persistence into adult life of a larval phase<sup>(1)</sup>; that the antennule has the club-shaped condition in some species of the South African *Mesamphisopus* seems to be a parallel case of retardation of development under similar sub-alpine conditions; its recurrence in various unrelated subterranean forms is open to the same explanation.

#### 4. Antennae

These, as in most Isopoda, have a peduncle consisting of five joints, of which two constitute the protopodite. The insertion is immediately below the eye and at its attachment the antero-lateral corner of the head is marked off above by a variably developed 'sub-ocular incisure', while below a well-marked ridge (in some cases, a groove) completes the boundary of a 'sub-ocular' area, suggesting the existence of a proximal protopodite joint<sup>(2)</sup> incorporated in the head which would give six joints to the peduncle and a third to the protopodite. In *Asellus*, where only five joints are seen, the missing joint is said to be the third which is incompletely fused with the second free joint; but in the *Asellidae* it should be noted, a sub-ocular incisure is not seen nor a sub-ocular area indicated. This well-marked sub-ocular area may be regarded as possibly a vestige of the more primitive condition in which six free peduncular joints were developed. The relative length or shortness of the antennae varies greatly in different species. In *tasmaniae*, for example, they may be as long as the body and many times longer than the antennule; species which have wholly adopted subterranean aquatic life also carry very long antennae, while in *terricola*, *latipes* or *kershawi* they are short, not greatly exceeding the antennule. It seems probable that the intermediate condition (with antennae of moderate length) was that of the ancestral form.

#### 5. The Mouth Parts

Chilton, in his account of *P. australis*, gives the first detailed description of these structures in a Phreatoicid, and recognizes the very evident likeness of the several appendages to the corresponding parts in *Asellus aquaticus*, so faithfully described by Sars (1867). That such a likeness between *P. australis* and *Asellus* spp. exists is not denied, but it is noteworthy that in Chilton's earlier account (of *P. typicus*) there was made no suggestion of any likeness whatever to the *Asellidae*, although almost every other Isopodan group was brought into the comparison and resemblances, even to Amphipod and Tanaid were noted. But *P. typicus*, notwithstanding its extreme specialization to subterranean life, nevertheless retains a less reduced, and, therefore, a less *Asellus*-like condition of the mouth parts. The fact seems to be that only in the reduced mouth parts of the more specialized Phreatoicids such as *P. australis* does the condition of these appendages make its closest approach to that of the *Asellidae*, and, if there should be any near phyletic relationship between the two groups (which is open to question), it might be feasible to derive the *Asellids* from an ancestral Phreatoicine stock rather than the reverse. It is more probable, however, that the relationship is but a distant one and these 'likenesses' may most reasonably be explained as due to parallel development in widely separated sub-orders. Indeed, this is to be expected where these creatures are living under closely comparable conditions and

(<sup>1</sup>) There is an analogous condition in the subterranean *Cruregens* which retains throughout life the larval condition of six peraeopoda only.

(<sup>2</sup>) But Bouvier (1902) and Hansen (1903) regard this as part of head and find a free first joint succeeding this (in *Bathynomus*, etc.).

both may be presumed to have inherited from a primitive Malacostracan ancestor those tendencies that have brought into being what Dennell (1937) calls a 'Peracaridan series' of feeding mechanisms. Although there are numerous minor differences between the mouth parts of the Phreatoicidae, they exhibit in general a condition which seems clearly to have arisen by a simplification of that which prevails in the Amphispodidae. In the latter family, while there is rather more variation in structure of the mouth parts, the condition is, nevertheless, one which could, in the main, be derived from that still persisting in the Mysidacea. It is, of course, improbable that the Phreatoicids had their origin from a Mysid stock, but the condition of the mouth and its various parts may, nevertheless, best be discussed by reference to, and comparison with, those of the Mysidacea.

*Mouth, Food-basin, and Food Current.*—It will be noted that, while the topography of the oral region (fig. 1) is, in general, like that of *Hemimysis* (Cannon and Manton, 1927, text fig. 1), two important differences may be distinguished. In the first place, the 'oral cavity' appears *relatively* more spacious. This is almost certainly correlated with the marked antero-posterior elongation of the body of the mandible in the Phreatoicids, whereas in the *Anaspididae*, in *Mysis*, and in *Apsudes* that appendage appears elongated in the dorsi-ventral plane. The mandible, too, seems to have developed a different type of articulation (see below, p. 11), which suggests that in Phreatoicids it may be capable of much more

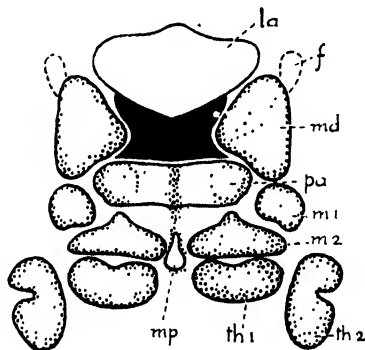


FIG. 1.—Ventral view of head of *Synamphisopus ambiguus* (Sheard) after removal of paired appendages.

The dark area indicates approximately the upper oral region.

m.1., maxillula; m.2., maxilla; mp., median process; th.1., maxilliped; th.2., gnathopod; other letters as in list on p. 5.

varied and complicated movement. Secondly, the succeeding mouth parts seem much more crowded together in a linear series. The paragnaths seem relatively more bulky, although their bases apparently do not extend so far posteriorly; the maxillula and maxilla of the Phreatoicids may retain (apart from the loss of palp and exopodite) the complexity of setal armature characteristic of the filtratory mechanism of other Peracarida, but have shifted their positions relative to each other. The maxillae (and maxillipeds) are closely approximated in the middle line (figs 1 and 2), and the maxillulae appear to have been squeezed out, to lie antero-laterally to the maxillae. Consequently, the spacious 'food basin' of such a form as *Hemimysis* is, in the Phreatoicids, represented by a greatly restricted cavity, being both short and narrow, while the 'food groove' which opens into it from behind is split (in some species at least) by a short, bent,

*median process*, undoubtedly the homologue of the structure so named in the Cumacea and not apparently recorded outside that sub-order, except in *Lophogaster* (Manton, 1928, *vide* Dennell, 1934).

The progressive crowding of these posterior mouth appendages (fig. 2), while it may be partly due to a shortening of the head, is more probably the consequence of a forward displacement of the first peraeon (second thoracic) segment and its appendage, the coxa of the gnathopod having in some species shifted its attachment to a position external (lateral) to that of the maxilliped instead of, as in *Hemimysis*, well behind it. To the comparable displacement in *Apseudes*, Dennell (1937, text fig. 1) has attached great importance, the forward movement being regarded, in that genus, as having a special significance in connexion with the respiratory (and feeding) current. Since such an explanation will not serve for

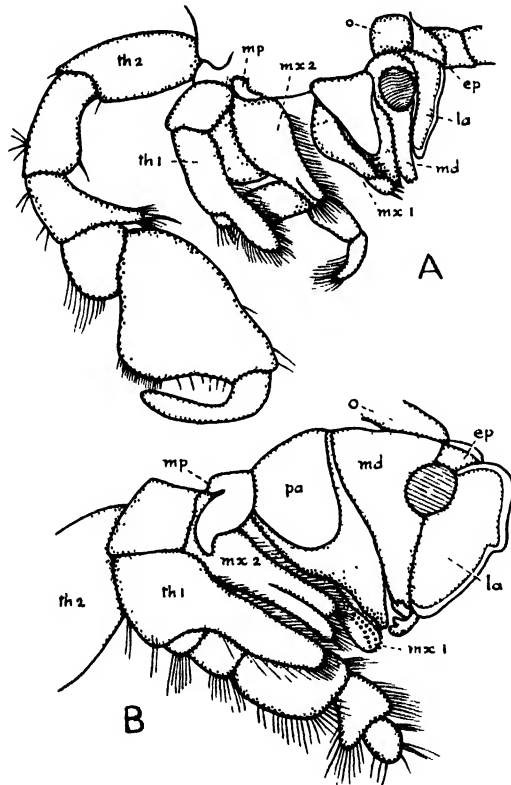


FIG. 2.

A.—Median section through the ventral part of the head of *Phreatoicus tasmaniae* G.M.T.

B.—A similar median section through the ventral part of the head of *Phreatoicopsis terricola*.

Spencer and Hall, to show increased crowding of mouth parts.

o., lower end of oesophageal tube; other lettering as for text-fig. 1.

Phreatoicids (respiration in this sub-order being the function of the pleopods), it may be suggested that it is an expression of the tendency towards more complete cephalization which is exhibited in varying degree in different orders of Crustacea and which has become so strongly developed in the Decapoda.



When the problem of the process of feeding in this group was first considered, it seemed probable that the movement of the pleopods in the relatively deep and narrow channel formed by the pleura of the pleon (a channel extended forwardly in some genera by the expanded bases of the adjacent peraeopods) might establish a current sufficiently strong to be effective as a 'food current', which, however, if it existed, would have functioned in fashion quite unlike that of Mysids. It proved unexpectedly difficult to observe accurately the feeding of these animals, since under natural conditions they feed only when at rest partly buried in the mud, but it has been found (in *P. palustris*, at least) that, although the waving of the pleopods is incessant, the movement, at rest, is so very slight that any current so set up is practically negligible. It can just be detected as a gently ingoing stream at the bases of the hinder peraeopods, the escaping water issuing from beneath the telson; experiments did, however, establish the fact that this movement of the water is not sufficient to disturb appreciably even the lightest of visible particles in the neighbourhood of the mouth. Nevertheless, since the maxillula and still more the maxilla and maxilliped are frequently found clogged with particles, it is practically certain that these appendages play an important part in the collection of food, and, since it is evident that there is no food current established by the swimming and respiratory pleopods, it seems obvious that the mouth parts themselves must be both the cause of the movement that disturbs the fine silt as well as the sieve that collects the disturbed particles. The setting in motion of the particles may, however, in part at least, result from the disturbance of the mud by movements of the head of the animal as it lies partly buried, or even of those of the anterior peraeopod, although, so far as the animal can be observed, it seems quiescent while feeding, except for a continual waving of the epipodite of the maxilliped. It is possible, therefore, that the absence of an overhanging carapace (so essential a structure in the more efficient of the filter-feeding mechanisms) is, perhaps, in part compensated in the Phreatoicids by the large development of the epipodite of the first thoracic appendage.

The various parts of this feeding mechanism must now be considered separately.

The *labrum* is relatively stout and comparable to that of *Hemimysis* or *Paranaspides*. It articulates with the epistome above by a variably irregular suture, and the whole structure exhibits a pronounced asymmetry doubtless in relation to the unequal condition of the mandibles. It is strongly and unevenly notched on either side, these gaps accommodating the mesial surface of the second joint of the mandibular palps and (in some species) the free end of the 'fulcral' process of the mandible. There seems to be no previous record of such an asymmetrical condition of the labrum either in this or any other Peracaridan group, although passing mention is made of asymmetry in the posterior edge of the labrum (which forms the anterior border of the functional mouth) in *Hemimysis* (Cannon and Manton, 1927, p. 223). The anterior face may bear a sub-median ridge which in some species rises to a blunt elevation, perhaps the rudiment (or the vestige) of the sub-rostral spine of Dennell's account of *Apseudes*. On either side of the ridge the surface may be concave, emphasising the low central elevation. In some Amphisopine forms, there is a characteristic, curved and interrupted, transverse row of long setae which forms a conspicuous moustache-like sub-marginal fringe.

The hinder wall of the 'oral cavity' is provided by the *labium* or *paragnaths*. This, too, agrees fairly closely with the condition figured for *Hemimysis* by Cannon and Manton (1927, pl. 2, fig. 2A), except that, in Phreatoicids the distal free border is not strongly bent forwardly. This posterior wall is incomplete

distally, being cleft in the middle, the gap apparently enlarging or diminishing with the separation or apposition of the two lateral halves. The free ventral edge is very heavily fringed with short, stiff, curved setae, and, in the Amphispine forms, a feature of unusual interest may be made out, for hidden among these fringing setae, there are, apparently, a number of short setospines. So dense is this fringe that it is most difficult to satisfy oneself that these spines really exist, but in some mounted preparations there has occurred considerable retraction of the living substance, and, in such cases, there seem to be (immediately within the chitinous covering) small heaps of protoplasm evidently withdrawn from the spines. If they have a real existence, it would seem possible that they are vestiges of a series of lappets of which, in *Apscudes*, only a single but well-developed pair remains; and in one Phreatoicine genus at least, these lappets seem to be represented by a single apical pair only.

It is in the *mandibles* (fig. 3) that we find the first notable departure from the Mysidacean or Syncaridan condition. These appendages form the lateral walls of the functional oral chamber and their bodies have undergone in the members of this group a considerable antero-posterior elongation which appears to be less, however, than in *Asellus*. Its actual articulation is seen on the lateral or ventrolateral border of the head as a comparatively short hinge line which may be horizontal or inclined obliquely. Internal to this hinge is an opening, variable in size and shape, through which the adductor muscle passes from its origin within the head. The movement of the mandible is, however, not merely a swinging one upon this support, but is modified by two outlying parts of its body, these being variably developed in different species. Anteriorly (and internally to the palp) there is a projection, angular, conical, or rounded, which fits into a related hollow below the sub-ocular area or onto the labrum or even the epistome. This projection is here referred to as the 'fulcral' process. Posteriorly, at a variable distance from the hinge, the body of the mandible projects postero-ventrally in a truncated free end which is concave where it abuts against the maxillipedal region of the head. This concave 'acetabular' process apparently moves upon a corresponding boss projecting from the head. So, at both ends of the body of the mandible, there is a feeble 'ball and socket' joint, and these, together, must modify the movements of the limb and probably contribute to the more effective grinding action of the molars. In some species (e.g., *littoralis*) the animals are often found preserved with the mandibles forwardly displaced so that the dentate edges are visible in front view, meeting in a nearly vertical plane immediately below the labrum. Normally, however, the teeth of the cutting edges meet in a horizontal plane behind the border of the labrum and, therefore, are visible only when examined from below. The possibility of such a difference in the position of the mandibles at rest is probably due to differences in the degree of mobility as determined by the size and position of the fulcral and acetabular articulations. Behind, and below the lower end of the acetabular process, the head may be forwardly produced into a buttress for the mandible, this being almost certainly the vestige of the structure so well developed as the setose 'posterior process' of the head in *Asellus*. In *tasmaniae*, there is a fine fur of setae here, but in other species, this process is unarmed and, in many, it is not developed.

The persistence of the 'lacinia mobilis' on the right mandible characterizes many species, and since such a condition is common to Syncarida as well as to members of several of the Peracaridan sub-orders, it must be accepted as a primitive character and its loss ascribed to an independent specialization within the group. It is likewise retained in the Cirolanidae, but in other Isopoda it appears to be generally wanting on the right mandible, so that its absence in the

Asellota cannot be considered as an indication of closer kinship with the Phreatoicoinea than with other Isopoda, while its occurrence in the Amphisopidae is evidence that the Phreatoicoidea are not derived from Asellote forms. In Amphipoda, as in Phreatoicoidea, a parallel evolution has taken place, both or only one (the left) of these laciniae being retained.

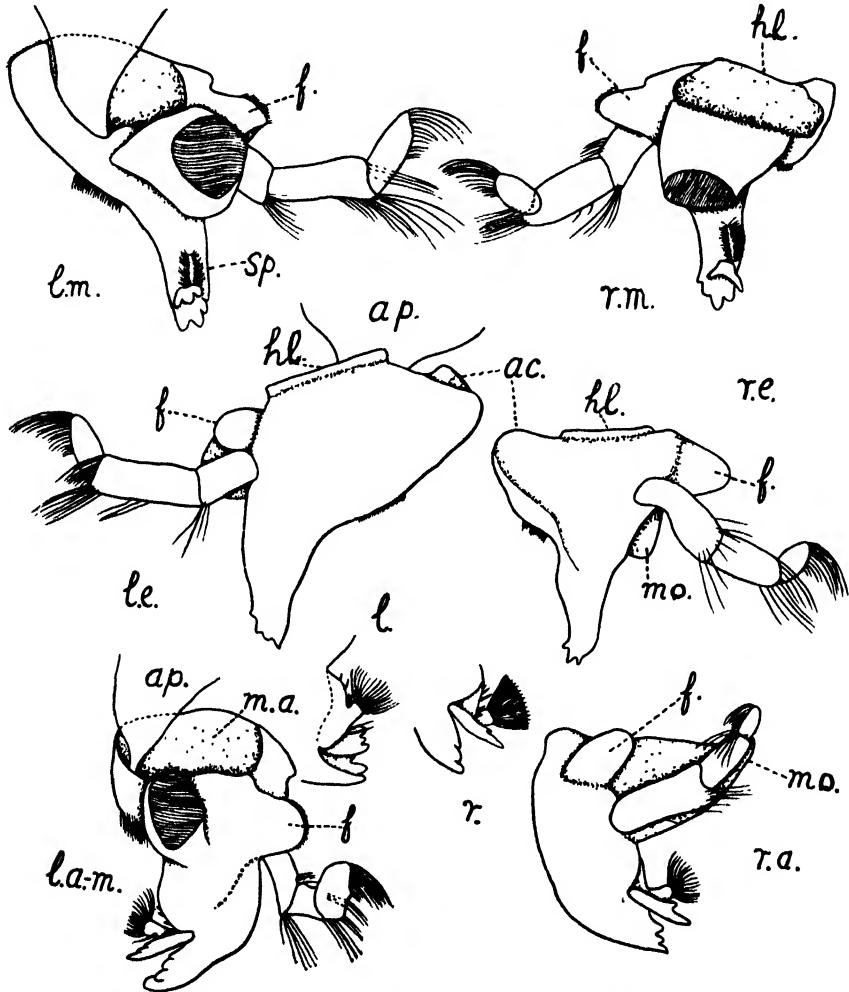


FIG. 3.—Mandibles of *Synamphisopus ambiguus* (Sheard). (For explanation of lettering see p. 5.)

The palp shows considerable range of structure. It retains the full number of joints found in Malacostraca and these may be sub-equal in length; alternatively, the first, the third, or both of these, may be considerably shortened. In Mysids, the palp has a quite short first joint, an extremely long second joint and the third is of moderate length and greatly widened. There can be little doubt that in these proportions of the mandibular joints, *Mysis* shows a specialised condition, and it seems probable that the more primitive condition was one in which the joints were cylindrical and of approximately equal length. In its setation, however

(as in that of other mouth parts), *Mysis* may have retained a generalized arrangement. The second joint has setae along both its entire mesial and lateral borders as well as a terminal comb, while the third joint is sickle-shaped, with several rows of setae along the outer concave border and a fur of fine setae clothing its mesial aspect. Such a condition is approached quite nearly in *tasmaniae*, where in one specimen there is, also, a large median sub-terminal seta reminiscent of the long and peculiar terminal seta of *Mysis*. In most other Phreatoicoidea the second joint is less fully armed, the terminal joint rarely has more than a single row of setae, and this row may greatly diminish in length while denticulate spines may replace pectinate setae.

Alongside the palp, immediately external to its basal joint, there was found, in two New Zealand specimens, a slender rod-like process, unjointed but otherwise closely resembling that which Smith has recorded as a vestigial exopodite in *Paranaspides*. Whatever it may represent, it is evidently of rare occurrence in this sub-order.

*Maxillula*. The description of the maxillula given by Sheppard for *tasmaniae* omits certain essential details of setal armature. A close examination of this appendage suggests that upon the endites there is retained a condition much more closely approaching that of *Apseudes* and of *Mysis* than existing descriptions would lead one to suppose.

It is generally recognized that among the smaller Crustacea, it is not unusual to find, associated with marked decrease in size of the animals, an increasing structural simplification of the mouth parts and reduction of armature, and therefore, while the retention of little-reduced and closely comparable mouth parts may fairly be considered as positive evidence of relationship, a marked decrease in the number of setae, spines, etc., does not preclude the possibility of comparatively close kinship. Thus the figures given by Sars (1867) of the condition in *Mysis relicta* show that the armature of this appendage has undergone some reduction as compared with the larger, but closely related, *M. oculata*. In the little *Hemimysis lamornae*, the figures of Cannon and Manton indicate that this reduction has been carried still further. It is of interest, therefore, to find that, while in the Phreatoicoidea simplification of the mouth parts has occurred, it seems not definitely related to decrease in size.

In *Mysis oculata* (fig. 4A)<sup>(1)</sup> the inner (proximal) endite is short and wide, its bluntly-pointed apex fringed by a row of slender spines directed both mesially and laterally; these are relatively numerous (fifteen), but only about eight (those mesially situated) are setospines, the lateral members of the series being stout and pectinate or feebly plumed. On the posterior face of the endite, and sub-terminal in position, is an irregular row of slightly pectinate or feebly-ciliated spines. Upon the outer (distal) endite, there is a treble row of terminal spines, and on its posterior face, also, is a sub-terminal row of about eight feebly-plumed setae. In *M. relicta* and *H. lamornae*, these same ranks of spines and setae are present, but with progressive reduction. Thus, in the latter species, it is stated that on the proximal endite there are *three* only of the terminal setospines, while of the sub-terminal rows on the posterior face of both endites in this species, as well as in *M. relicta*, there seem to be but three or four spines or setae.

In the Phreatoicoidea (fig. 4B), the general conditions are much the same, but the *shape* of the inner endite has been greatly modified, the lateral half (with

(<sup>1</sup>) Figures by Hansen of maxillula and maxilla of *Mysis oculata* occur in several text books (e.g. Calman, 1909), but reference to Hansen's paper is not readily found. Apparently details of setal armature were not furnished and the figures here given are drawn from preparations made from specimens of *M. oculata* kindly supplied by Prof. Hanström of the University of Lund.

its fringe of feebly-plumed setae) having apparently disappeared. Generally, it will bear a larger number (ten to six) of setospines in the Amphispopine forms and a smaller (four to three) in Phreatoicinae; the sub-terminal row of spines varies in numbers from four to two and it has shifted to a position practically apical. The outer endite is less modified and may still retain a threefold<sup>(1)</sup> row

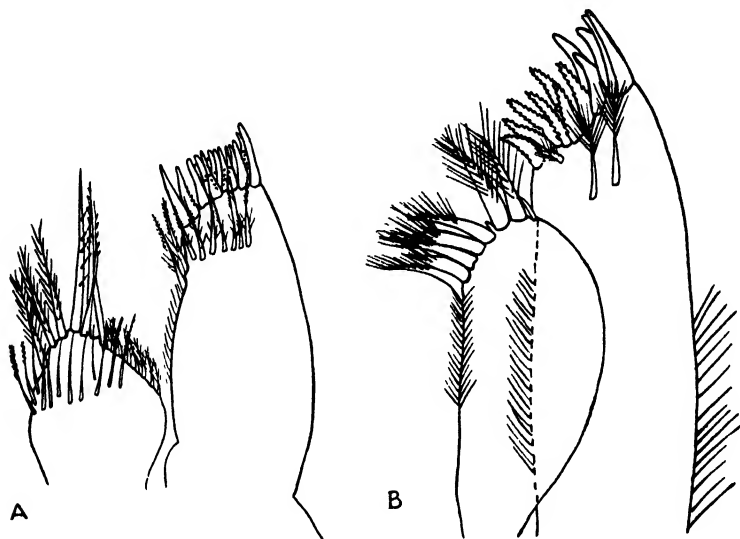


FIG. 4.

A.—Part of maxillula, in posterior view, of *Mysis oculata*.

B.—Part of maxillula, in posterior view, of *Amphispopus lintoni*.

of terminal spines, but these may decrease to a double rank; the sub-marginal plumose setae, however, retain the position found in *Mysis*, but they are never more than four in number and may be reduced to two or one. In a few species, this series seems to have vanished completely. The fact that in *Mysis* and in the Tanaioidea (as well as in some sub-orders of Isopods) both of these rows of spines and of setae on both endites are well represented lends further support to the view that the occurrence of a small number only in some Phreatoicids (and Asellids) is to be interpreted as due to reduction, while the retention of the more complete series represents most nearly the primitive condition.

**Maxilla.** A similar story is to be told of the maxilla, but here the reduction in *M. relicta* from the condition retained by *M. oculata* is more marked. Fig. 5A represents an anterior view of the maxilla of this latter and should be compared with the figures given by Stebbing (1893, p. 272, fig. 23) for *M. relicta*. In *M. oculata*, the outline of the rounded basal lobe of the proximal endite is much more definite, its mesial edge has the characteristic comb-like row of close-set filtratory setae (fil.), but, in this species, the row is continued around the margin onto the anterior face of the endite, almost to the junction with the base of the palp. Sub-marginally, too (upon the anterior face), is an irregular row of about

(<sup>1</sup>) In *P. terricola* there are actually four ranks present, although not all of these are complete.

seven stout plumed spines (*a.s.*), of which, in Sars' figure of *M. relictæ*, only three are shown as persisting. In Phreatoicids this sub-marginal series has practically disappeared, only one of these (apparently the most mesial) being retained, and this one very variably. In some species of Phreatoicids, however, there is an entire line of fine setae anteriorly paralleling the filtratory (*a.s.*, in figs 5C and 5D).

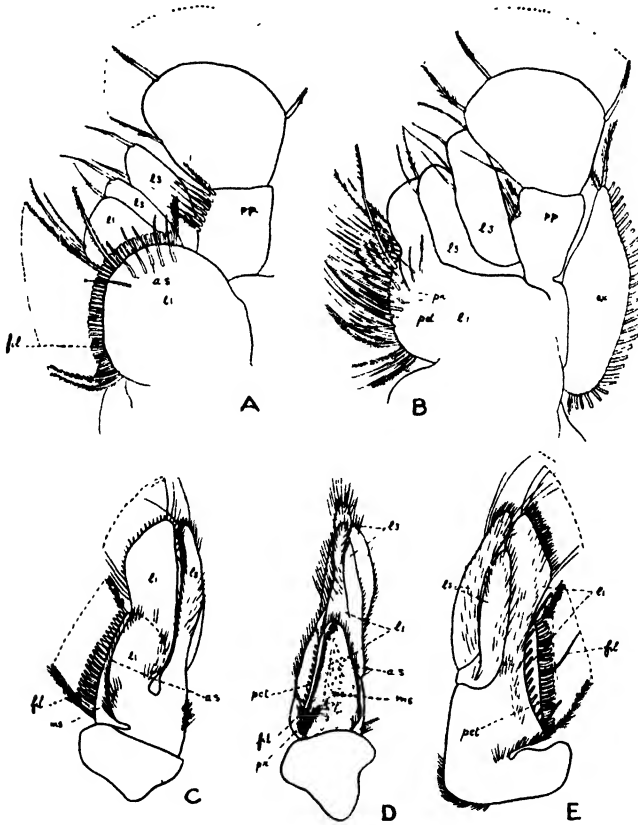


FIG. 5.

Maxilla of *Mysis oculata* (A, anterior view; B, posterior view).

Maxilla of *Synamphisopus ambiguus* (C, anterior view, D, mesial view; E, posterior view).

The distal part of the proximal endite is relatively large and appears better defined in *M. oculata* than in *M. relictæ*, where it is shortened and set at a lesser angle. In both species, the mesial edge of this distal region is armed with a series of pectinate setae, the continuation of a rank which arises near the base of the rounded proximal region (fig. 5B, *pct.*) immediately adjacent and posterior to the filtratory setae. It is this posterior row of setae which is said by Cannon and Manton to serve in protecting the filtratory setae from the action of the brushing setae on the maxilliped. In the Phreatoicoidea both these rows of setae

occur with the same general arrangement, fringing the posterior edge of a sub-triangular mesial surface. The anterior edge of this surface may also bear a rank of setae—usually simple—well developed in *Synamphisopus*, but the proximal endite itself shows a considerable range of variation. The rounded basal part is variably marked off from the apical portion: the filtratory setae may be confined to this basal part which may be considerably reduced, or the two portions (basal and distal) may no longer be distinct but pass smoothly one into the other and the filtratory setae may then range almost to the apex.<sup>(1)</sup>

Viewed from behind, there is in *M. oculata* another (a fourth) series of setae (fig. 5B, *pr.*), sub-marginal in position. In some Phreatoicids a belt of setae occupying a comparable position may represent this hindermost series (fig. 5D, *pr.*).

The two endites of the third segment of *Mysis* resemble closely the distal part of the proximal endite and the armature is similar. This is equally true of many Phreatoicids, although in this region, too, a good deal of variation may occur, and since in the Phreatoicids the palp has disappeared, there is a tendency for the outer of these two endites to move anteriorly (into the place of the missing palp) and partly to ensheath the middle plate.

At this point, the likeness between *Mysis* and Phreatoicids ends, for, in the latter, palp and exopodite (both of which play essential roles in the filtratory mechanism as interpreted by Cannon and Manton) are absent. Distinct tufts of setae are present however, and may mark the position of the vanished structures.

The Phreatoicid maxilla seems closely to resemble the condition figured by Dennell for this appendage in *Apseudes talpa*. In that form the basal and distal parts of the proximal endite are represented as very like those of *Mysis* and of some Phreatoicids, and Dennell apparently gives no reason for the suggestion (in his figure) that this distal part of the first endite has united with the inner endite of the third segment. That this latter endite has vanished would seem a more probable explanation, but external to the proximal endite two structures are shown which appear to be exactly comparable with the two endites of the third segment of *Mysis* and of Phreatoicids; the outermost is, however, in *Apseudes*, indicated as the palp.

*Median process* (fig. 2, *mp.*). Immediately behind the maxillae, in the middle line, there occurs in several Phreatoicid species a small bent process, homologous with the median process so conspicuous in Cumacea. According to Dennell, it has been found by Manton in a rudimentary condition in a primitive Mysidacean (*Lophogaster*). Reference to this structure will be made at a later stage.

*Maxilliped*. In most Phreatoicids, this appendage has its attachment very close to the maxilla. The coxae in some species are relatively long, but as a rule this joint is shortened. In the female it bears a large lobe projecting stiffly backwardly into the brood-pouch, its free edge furnished with a fringe of slender plumed or recurved setae. This plate is found in a reduced condition in the males of some species. Each basis bears a long endite produced anteriorly and dorsally, those of opposite sides being linked together by a longer or shorter series of coupling hooks which obviously are modified members of the series of pectinate spines which arm the ventro-mesial border of the endite.

The dorsal (morphologically anterior) edge of the endite bears a row of plumose brush setae which may extend the length of the endite or be restricted to its distal part. From the latero-distal angle of the basis springs a stout plumed spine which probably marks the point where the exopodite once was carried.

(1) *Asellus* shows an advanced stage in the specialization of this endite.

The palp varies in length; in some species so long that the distal joints may be upturned in front of the labrum.

Throughout the sub-order, the epipodite is well developed, springing by a wide base from the lateral aspect of the coxa.

### 6. Cervical Groove and Maxilliped Segment

Near the hinder border of the head, there is normally a transverse groove running dorsally from the postero-inferior angle. In some forms, e.g., *Mesamphisopus* (fig. 6, 2s.) this can be readily traced to the actual ventro-lateral border. In many cases, it is but feebly developed and may rise from the posterior, rather than the ventro-lateral border, and only in *brevicaudatus* does it meet its fellow dorsally—in all other cases being incomplete. In the majority of Amphispine forms it is practically obsolete. There can be little doubt that it marks the original boundary between the segment bearing the maxilliped and the primary head in front; the segment widens above, where it may show the vestige of a segmental transverse ridge, but below may be reduced to a very narrow edge.

### 7. Transverse Ridges on Peraeon

The occurrence on the segments of the peraeon of strongly marked transverse ridges armed with stout setae or spines is comparatively rare in this group. It occurs notably in a few Great Lake species, while in *Eophreaticus* there is a marked and comparable wrinkling which extends onto the pleon segments, also. It is more usual to find the body somewhat feebly wrinkled or practically smooth, this latter particularly in subterranean forms. It is of interest, however, to note that in many, including some of these underground species, the distribution of setae is suggestive of the obsolescence of such ridges. In the one specimen of the fossil *wianamattensis* which has been examined and which displays the dorsal view, a strong wrinkling near the forward and hinder border of the peraeon segments was evident. It seems highly probable that such ridging was developed in the ancestral Phreaticoid, and in this connexion it should be noted that in Packard's restoration of *Acanthotelson* there is a suggestion of a similar condition, as also in Calman's figure of *Pleurocaris annulatus*, which was, according to that author, closely related to *Acanthotelson*.

### 8. Expansion of First Peraeon Segment

The expansion of the first peraeon (second thoracic) segment (widening latero-ventrally) and its union with the head (a vestigial condition of a carapace which does not, however, hang free below) might be regarded as a condition retained in the more primitive members of the group, the last trace of this part of the caridoid facies. This tendency to expand the first peraeon segment ventro-laterally occurs, however, both in those forms in which the head is short and all traces of the cervical groove have disappeared as well as in those in which the head is longer and the maxilliped segment well-defined or even nearly complete and in which, too, the first peraeon segment is still free. Again, a choice of two explanations is available. It is fairly generally accepted that the caridoid facies (which includes a well-developed carapace) has undergone retrogression to a variable extent in the Syncarida, Amphipoda, and Isopoda. If that be so, it may be considered that it is the short-headed (Amphispine) form which most nearly retains the ancestral condition, the structure of the Phreaticine forms being derived by still further recession from the caridoid type; the first peraeon segment



regains its freedom from the head and may become secondarily elongated till it equals or exceeds the length of the succeeding segments (particularly in elongate subterranean forms) and the maxilliped segment reappears, till it may be practically as much in evidence as in the more primitive Syncarida—this view supposing as possible a reversal of evolutionary tendencies and the recovery of lost or nearly lost structures. In the alternative, it may be supposed that, in this feature, the Phreatoicine condition is the more primitive, that a carapace (if once present in the evolutionary history of this sub-order) was a backward development of the head only and left free, beneath it, all the thoracic segments (including that of the maxilliped) so that it could disappear (as is supposed to have happened in the Syncarida) without affecting thoracic segments; the latter view would suggest for the Phreatoicids a kinship, or at least a parallel evolution with the Syncarida.

Another point of interest in this connexion is that this widening of the first peraeon segment ventrally is usually associated in the Amphisopidae with a greatly-developed coxa of the gnathopod—the coxa having come to lie externally to the base of the maxilliped as it does in *Apsaudes* and the Cumacea. It is difficult to believe that this was the earlier condition which is disappearing (by backward shift) in the Phreatoicinae.

In those Phreatoicids which seem in many respects to be the most primitive of living species, *M. capensis* and *E. kershawi*, the first peraeon segment is not at all, or very little, expanded below.<sup>(1)</sup> In the former, the coxa of the gnathopod lies so far back as to leave wholly uncovered the maxilliped segment and even, in some specimens, to expose the postero-ventral corner of the head. This is true of *Hyperoedesipus*, also. The *fusion* or the *freedom* of the coxae of peraeopods is related to this matter. It would naturally be supposed that the freedom of these joints was the primitive state and the fixed condition a later development—yet *Mesamphisopus* shows them seemingly united to their segments, while they reach the greatest degree of freedom in the Phreatoicidae.

### 9. Vestigial Structures on Peraeopods

Upon the antero-proximal border of the basis of the second, third, and fourth peraeopods of *E. kershawi* and probably in the fossil *wianamattensis*, there is developed a strong boss armed with a cluster of stout spines, and this may be developed even when the remainder of the basis is unarmed. It seems possible that there is here the last trace of a vanished exopodite, for it is in this position (i.e., near the proximal end of the basis) on the more anterior peraeopods that the exopodite is found in some Tanaioidea. In certain members of that order, the exopodite is reduced to small tufted knobs differing, in degree only, from those found in some Amphisopidae.

### 10. The Hinder Peraeopods

The Phreatoicids are quite exceptional among Isopoda in that the body appears compressed. While this appearance is due in part to the downward extension of the pleura in the pleon, an expansion of the bases of the three hinder peraeopods contributes largely to enhance it. The forms in which this condition is well developed are those capable of swimming strongly, and there can be little doubt that this deepening of the channel in which the pleopods sweep makes these appendages more effective as natatory organs.

<sup>(1)</sup> According to Barnard (1914, p. 284) it is in *M. capensis* actually longest in the mid-dorsal line.

In *Eophreatoicus* other joints than the bases are also expanded. In Amphipoda the enlargement of these more distal joints is frequently associated with the burrowing habit, but this explanation apparently will not serve for *Eophreatoicus*, which is said to be found swimming in cold, clear water. *Phreatomerus latipes*, too, was taken swimming against a strongly flowing current.<sup>(1)</sup> The Triassic fossil *wianamattensis*, likewise, shows the bases of all peraeopods moderately expanded, as well as the merus of some at least of the anterior limbs, in this resembling *Eophreatoicus*. Walking or creeping Phreatoicids (including subterranean forms), on the other hand, usually have the bases little widened, and in some species the whole leg is slender. There are, however, exceptions to this rule, the bases of the fifth to seventh peraeopods being moderately wide, for example, in *pearsoni*, *australis*, and *assimilis*.

It seems probable, then, that the hinder peraeopoda of the primitive Phreatoicid had more or less uniformly widened bases, which have undergone a varying degree of reduction in most Phreatoicidae, whereas in the majority of surface-living Amphisopine forms, the bases of the hinder peraeopods have become increasingly expanded.

### 11. Oostegites

In the retention of functional oostegites on the first four peraeon segments, associated in some species with what are almost certainly vestiges of these upon the maxilliped (the 'coxal lobe'), and (in one or two genera) of vestiges of a more posterior pair on the fifth peraeon segment, we have in this group a better development of these structures than in most of the Peracarida. In some of the Mysidae—in so many features primitive—this particular character is found to be highly specialized, the brood-pouch reduced and oostegites restricted to a few (the hindmost) peraeopods, but in several Mysidacean families seven pairs of thoracic oostegites are found, a condition seen in the Carboniferous *Pygocephalus* and almost certainly that of the primitive Peracarida. In the Isopoda some Cymothoidae (e.g., *Aega*) are said to retain the full seven pairs, but sixth and seventh are small.

Concerning the homologies of these structures, Claus (1885) has suggested that they may perhaps be modified epipodites, a suggestion which, while it is in keeping with their origin from the coxa, requires that they should have shifted from the outer to the inner aspect of that joint. That may have come about by a rotation, in the first four, of the entire limb, and it is noteworthy that these, if expanded, are widened anteriorly. In many, a partial rotation still exists. The failure, in the hinder three, to undergo this rotation would explain the division of the legs into two groups. Such an explanation might perhaps serve equally well to explain the presence of gill as well as of oostegite in the Amphipoda as outgrowths of this coxal joint (and equivalent to the *two* epipodites of the Syncarida), but a difficulty would arise in the case of those quite numerous Amphipods in which *two* gills are present in relation to each limb (as well as oostegite in female) unless we suppose that the two gills have come about by the subdivision of one epipodite.

As an alternative, it seems possible that the oostegite might be a much modified gnathobase and that the coupling lobes of the pleopods are equally derived

(<sup>1</sup>) It is of interest that in localities where Amphipod (Neoniphargid) and Phreatoicid occur together, they may usually be readily separated by emptying the debris picked up by the scoop upon the slope of a boulder. The Amphipods will usually slide and scramble *down* the slope; the Phreatoicids clamber upwards *against* the downward trickle of mud and water.

from these same structures co-existing, in the pleopods, with a normally placed epipodite. It is possible, too, that the coxal structure on the seventh peraeopod of the male, into which runs the vas deferens, should be regarded as a still more modified member of this series which would then extend, almost without an interruption, from maxilliped<sup>(1)</sup> to fifth pleopod. Such a derivation, whether from gnathobase or epipodite might explain the occasional development of brood lamellae in the male or of penes in the female, these structures having arisen from appendages primarily unrelated to sex.

## 12. Median Sternal Processes

The occurrence of one or more median sternal processes is probably to be explained as the retention of a part of a linear series, once perhaps segmental in character in an ancestral Peracaridan. Such median sternal down-growths occur in some Gammarids, Caprellids, Anthurids, and in the Tanaioidea.

In *Hyperoedesipus* and *Phreatoicoidea*, laterally compressed median spines occur somewhat variably on the peraeon segments; in *Eophreatoicus* and *Amphisopus*, a median elevation on the first pleon segment, and sometimes on the second also, is probably a remnant of this same series; in *Phreatoicopsis terricola*, in addition to the median process just anterior to the maxillipeds, there is found a stout conical boss between the gnathopods and others on the first four pleon segments. In *M. tasmaniae* (G.M.T.), the median process on the head and two processes (on the first and second pleon segments) appear; in *M. setosus* sp. n., the median process is particularly well developed. In *Synamphisopus ambiguus* (Sheard), only this anterior member of the series persists and there can be little doubt that this is the structure which has been modified and pressed into service as a mouth part in the Cumacea.

## 13. Pleopods

It would seem that the primitive condition of these appendages must have been one in which the two lamellar rami were equal in size, similar in shape and both fringed with the typical (natatory) plumose setae, a condition characteristic of Apseudidae and many Isopoda and one which, in the Phreatoicoidea comes nearest realization in *Mesamphisopus*. In this genus, as in all Phreatoicids, an almost exact similarity in shape is restricted to the first pleopod, the succeeding pleopods all showing an exopodite freely separated into two lobes, a condition hinted at, but nowhere so well developed in other Isopodan sub-orders (Anthurids, Cirolanids, Asellids, and Stenetriids) as well as in some Apseudids. Apart from this difference, however, the two lamellae are, in *Mesamphisopus*, very similar in length and breadth; the endopodite, though decreasing somewhat in size, retains, in all the pleopods, a variable number of the plumose setae, which, however, show an increasing tendency to become simple in the more posterior appendages. In *Notamphisopus*, too, the first pleopods show this presumably primitive shape and both lamellae are more nearly equally setose, but in the succeeding pleopods one lamella (the endopodite) is bare of setae and decreases progressively in size. In *Eophreatoicus*, which appears in many respects to be primitive, this practical equality in size and similarity in shape is preserved in all the pleopods, but the fringe of plumose setae is wholly wanting from all the endopodites. The persistence of

(<sup>1</sup>) The co-existence of epipodite and oostegite (coxal lobe) upon the maxilliped is not incompatible with the above suggestion, for while the epipodite retains its normal lateral position the coxal lobe arises from the posterior (morphologically external) surface, but it is nevertheless, mesial in position and could correspond with a gnathobase.

plumose setae upon the endopodite of the South African *Mesamphisopus* and the New Zealand *Notamphisopus* has a feeble counterpart in a Tasmanian species, *Hypsimetopus intrusor* Sayce, where three or four plumed setae persist apically on the first pleopod. Since these setae are obviously the remains of a natatory apparatus in forms, none of which now retain the free swimming habit, while in many of the Amphisopine forms, which are strong swimmers, this setose condition of the endopodite has disappeared, the retention of these non-functional vestiges in three widely separated genera has clearly an important phyletic significance. The penial stylet which is developed from the mesial border of the endopodite bears, in many species, setae and spines, a retention possibly of the setae which formed the primitive fringe of that border.

It should be noted that in *M. tasmaniac*, the exopodite of the first pleopod is unusual in that it bears laterally a few stout marginal spines as well as setae; in *Hyperoedesipus*, alone, are plumose setae retained along the whole length of the mesial border in the first pleopod, while in *Hypsimetopus* this border is bare of setae.

The epipodites found in Phreatoicids upon the third, fourth, and fifth pleopods constitute a feature peculiar to this sub-order. What may perhaps be traces of these, fused with the sympodite of first and second pleopods, are found in several genera, but only in *Eophreatoicus* is there found a fully-developed free epipodite upon the second pleopod, once again, it must be assumed, the retention of a more ancient condition.

#### 14. Coupling Hooks

The presence of coupling hooks on the sympodite of the pleopods could be interpreted as a modification (within the Phreatoicoidea) of the entangling setae,<sup>(1)</sup> but since similar coupling hooks are found on the pleopods of many Amphipoda, Cumacea, and Tanaoidea as well as in many of the other sub-orders of the Isopoda, these, too, are probably correctly interpreted as representing the retention of a once general Peracaridan feature and their absence regarded as a specialization due to loss. Possibly the ancestral Phreatoicid had both coupling hooks and setae. This suggestion is supported by the fact that coupling hooks may arise directly from the sympodite, whereas entangling setae are nearly always carried on strongly-developed outgrowths (coupling lobes) of the sympodite—a consequence of the mode of functioning of these setae which seems to require them to spring practically vertically from an outstanding lobe; were the coupling hooks a secondary acquisition, independently arising within the sub-order, the lobes might have been expected to have been retained more completely. If, as suggested earlier, these coupling lobes are remnants of gnathobasic outgrowths, once present on all appendages, there may have been a regression of these structures, more noticeable in those genera that retain coupling hooks than in those that link the pleopods by entangling setae only.

#### 15. The Penial Stylet

The penial stylet, too, is found in two widely different forms; that characteristic of most of the Amphisopine forms is stout, strongly curved, tapering to a point and devoid of terminal spines; the alternative condition is that of a simple, incomplete, cylindrical tube with a terminal fringe of stout spines (with, in some cases, a sub-terminal series as well). This latter prevails throughout the Phreatoicidae, but is seen in its simplest form in one Amphisopine genus (*Mesamphisopus*)

(1) Just as setae have been modified and developed into coupling hooks on the maxilliped.

and a little modified in *Hyperoedesipus*. In *Hypsometopus* and *Phreatoicoides* there are modifications of the Amphisopine condition. In this stylet we have, apparently, something new developed within the Isopoda, with no counterpart amongst Mysids, Syncarids, Amphipoda, or Tanaioidea.

#### 16. Tailpiece

The condition of the tailpiece, or rather the telsonic apex of that region, again provides an interesting problem. Is the condition seen in *M. tasmaniae* (so reminiscent of the telsonic spine of *Acanthotelson*) a primitive or a secondary feature? In many of its characters, *tasmaniae* is linked with the more specialized (presumably more modern) Phreatoicidae, while yet retaining some distinctive primitive features. In those forms in which there is the greatest aggregation of primitive features, the telsonic projection is minute or absent.

#### 17. Dorsal Flange on Uropod

Another interesting, but variable, feature is the development of a thin dorsal flange along the inner border of the peduncle of the uropod. In almost every species, the distal mesial angle, at least, is strongly produced, being armed with a couple of particularly stout spines. In two or three genera, included here as among the more primitive, this mesial process may be found greatly enlarged at its maximum development, giving to the uropods the appearance of possessing a third ramus as stout as the two normally present.

A comparable development of the peduncle is found in at least one other Isopod group, the Cymothoidea,<sup>(1)</sup> the retention of this character in some Phreatoicids providing further support for the suggestion of the origin of this sub-order from a very generalized form near the base of the Isopodan series.

#### 18. Uropodal Rami

The occurrence, in some Amphisopine genera, of bluntly truncated uropodal rami with a terminal, stout, freely movable spine, suggests the possibility that there is represented here a two-jointed ramus,<sup>(2)</sup> in which case the sharply-pointed apex to the rami in the Phreatoicine forms is to be regarded as the product of fusion of these parts, i.e., the final *loss of freedom* of the terminal joint.

*Hyperoedesipus* seems to show a stage in which this loss of freedom is already accomplished in the inner ramus, but the outer ramus, which is stout, narrows abruptly at the transition into the terminal spine, as though the incorporation of the terminal piece had not been well established. There has been found nothing in support of the alternative view that the freedom of this terminal joint has resulted from the development in the Amphisopinae of an articulation here; the condition found in *Eophreatoicus*, *Mesamphisopus*, *Amphisopus*, etc., must presumably be regarded as that once general for the sub-order.

#### 19. Typhlosole

A typhlosole, of variable extent, is found in the great majority of genera. The figure given by G. Smith is accurate for *Phreatoicopsis*, and this condition is closely approached in *Synamphisopus*. In most forms, however, the fold is more

<sup>(1)</sup> Cirolanidae (Cirolana, Exocorallana, Rocinela, etc.). In some Idotheoidea (e.g. *Austriodotea*) it is perhaps represented by the single mesial spine.

<sup>(2)</sup> The fact that in Mysids, Tanaioidea, numerous Amphipods and many other Isopods, the uropodal rami are two or many-jointed supports the view that in the Amphisopidae there is retained the last trace in the Phreatoicoidea of the more primitive multi-articulate uropod.

simple, recalling the condition existing in many Earthworms, excepting that it is ventral, instead of dorsal, in position. Barnard (1927, pp. 144-5), who questions the accuracy of Smith's statement, apparently had for examination no specimen of *Phreatoicopsis* and was unlucky in that *Mesamphisopus*, of which he had abundant material, is one of the few Phreatoicids lacking a recognizable typhlosole. While it is possible that this structure is a development peculiar to this sub-order, some of the least specialized Oniscoidea seem to have it in a reduced (or perhaps rudimentary) condition (e.g., *Ligia*, Hewett, pl. 2, fig. 16).

## 20. Quasi-hermaphrodite

The quasi-hermaphrodite state may be considered either as a primitive condition persisting in a few forms or as a variably developing new condition; its known distribution in the sub-order points to the former.<sup>(1)</sup> There is no information available concerning the condition of the internal organs, and, as suggested above, the repetition of coxal outgrowths along the series of peraeon appendages may have been originally unrelated to sex.

## 21. Comparative Sizes of Body Parts

One other matter may perhaps be most conveniently considered here. It concerns the comparative lengths of the several regions of the body and also of individual body segments. The comparative length of the different regions of the body, as well as of individual segments, is generally regarded as having a considerable importance for systematic purposes. From several causes, however, measurements made from preserved material may yield discrepant results. In the first place, there can be a notable variation in the degree of extension of the intersegmental rings in the peraeon, but, in addition, the degree of exposure (or concealment) of the segments themselves may, likewise, vary considerably. The *posterior* border of the head and the *anterior* border of the second to seventh peraeon segments may consist of an incomplete hoop of scarcely calcified chitin which is thinner and lies at a level somewhat below that of the general surface of the rest of the segmental ring. In the South African species, particularly, these bevelled articular borders are well developed and may be exposed to a variable extent, or, under-riding the next adjacent tergum, may be completely hidden. Of the peraeon segments, the first alone lacks this smooth bevelled border. It may over-ride both the head and the second peraeon segment to a quite variable extent, or it may be found quite separate from one or both by a more or less considerable intersegmental gap, or, in other species, wholly fused with the head. In any case, the first peraeon segment, alone, must always display its full length, whereas in the succeeding segments, the whole or part of the free (under-riding) anterior margin may be exposed or hidden from view. It will be obvious, then, that the length of the head and of the second to seventh peraeon segments will individually be liable to under-estimation. On the other hand, the combined length of head and peraeon may be, quite appreciably, either over- or under-estimated.

In the pleon, intersegmental gaps are rarely found, but a certain amount of telescoping of these pleon rings may nevertheless occur, when the body is straightened, or there may be brought about the maximum extension dorsally when the pleon is downturned and carried more or less beneath the body. In these circumstances, the visible length of pleon segments (particularly the fifth

<sup>(1)</sup> A functional hermaphroditism is said to occur in another generalized Isopod sub-order—the *Cymothoidea*.

and sixth) may vary quite markedly. Accordingly, in the fully contracted state, the total length of head and peraeon is quite considerably less than the total length of the constituent parts, and comparisons made by different authors concerning the relative length of different regions may afford quite conflicting results. For purpose of comparison, therefore, measurements of regions should be made, if possible, on specimens which are sufficiently relaxed to show the whole of the body rings but not to display the uncalcified intersegmental membrane. In measuring the length of the head, the horizontal distance between two verticals drawn from the anterior border of the ocular lobe and the hinder articular margin respectively should be taken and should include the (posterior) under-riding articular border.

## SYSTEMATIC

### Order Isopoda

Peracarida without distinct overhanging carapace, although both first and second thoracic somites may be united with head. Body generally strongly flattened dorsi-ventrally (except Phreatoicoidea); telson usually united with last somite. Antennules uniramous (except in *Bathynomus*), antennae rarely with minute exopodites; thoracic limbs without exopodites; first pair (maxillipedes), with epipodites, not enclosed in branchial cavity but which, when well developed, may replace functionally the overhang of carapace; seven remaining pairs, all similar or variously modified, coxae always short, often fused with body and expanded laterally, ischia *relatively long*. Pleopoda typically biramous with lamellar branchial (sometimes natatory) rami, the second pair, and sometimes the first also, modified in the male. Heart lying wholly or in part in the abdomen; the young leave the brood-pouch before the appearance of the last pair of thoracic limbs. Some may be hermaphrodite.

The probable position of the sub-order Phreatoicoidea within the group is, in the opinion of the present writer, indicated by the following

#### KEY TO THE SUB-ORDERS OF ISOPODA<sup>(1)</sup>

##### A. Uropoda lateral—

C. Body sub-cylindrical, fusiform; pleon appearing compressed. Uropoda ambulatory; pleopoda natatory and respiratory *Phreatoicoidea*

##### D. Body depressed, (semi-cylindrical):

E. Uropoda forming, with tailpiece, a caudal fan; pleopods natatory and respiratory *Cymothoidea*

F. Uropoda valve-like, inflexed, meeting beneath pleopoda which are largely branchial *Idoteoidea*

##### B. Uropoda terminal, body depressed—

##### G. Pleopoda exclusively branchial:

J. First pair generally modified into a thin opercular plate *Aselloidea*

K. Pleopoda never covered by opercular plate. Parasitic forms *Bopyroidea*

H. Pleopoda adapted for air breathing *Oniscoida*

### Sub-order PHREATOICOIDEA

Body sub-cylindrical and fusiform, the pleon appearing compressed chiefly on account of the strong downward development of the pleura; the first thoracic segment generally ill-defined and always forming part of the head, the second thoracic (first peraeon) segment may be free or fused with the head. Eyes large, small

<sup>(1)</sup> This is a modification of the key published by Richardson (1905, p. 3).

or absent; when present may be widely separated or relatively near to each other. Antennules and antennae unequal in length, a peduncle usually clearly marked off from a flagellum, exopodite invariably wanting. Mouth parts primitive, upper lip asymmetrical, the freely movable labrum depending from a stout interantennal plate (epistome); mandibles have a three-jointed palp, a 'pars incisiva', a lacinia mobilis (which may be present on both mandibles or on left mandible only), spine-row and molar. The spine-row is, in some, separated from molar by a row of free setae and is itself mounted on a raised elongate base. Maxillula, proximal endite with many (nine or ten) to few (two or three) terminal setospines; median process may be present immediately in front of maxilliped (cf. Cumacea); maxilliped well developed, coxa with epipodite, and, in mature females, with vestige of oostegite, outer distal angle of basis with strong plumose spine, palp long, five-jointed.

Peraeon with six or seven free segments, the seven pairs of peraeopods being divided into an anterior group of four, directed forwardly, and a hinder group of three generally turned backwardly. Of these, the first pair is always prehensile (sub-chelate), the second, third and fourth are ambulatory and rarely prehensile (except in the male, the fourth, which is very generally sexually modified), the last three pairs ambulatory and capable of being raised over the back as in Amphipoda. The incubatory pouch consists normally of four pairs of brood lamellae, but there may be vestiges of two other pairs, one more anterior (maxilliped) and one posterior (fifth peraeopod). The penes are usually long and arise, widely separated, from the coxae of the seventh peraeopods. Pleon generally long, with six distinct segments, fifth always longest (cf. Cumacea), sixth firmly united with telson. Pleopods well developed, adapted for both swimming and breathing; the exopodite, in all but the first, with two distinct joints; second pair, modified in the male, with a penial stylet arising from the mesial border of the endopodite; the hindmost three (or four) pairs bear a free epipodite.<sup>(1)</sup> Suture between sixth pleon segment and telson more or less strongly developed. The uropoda are lateral and biramous and are used in locomotion; the peduncle may be strongly produced into a disto-mesial process.

The sub-order contains but two families, distinguished by the condition of the mandible:

I. *Family Amphisopidae.*

Both mandibles with lacinia mobilis.

II. *Family Phreatoicidae.*

Only the left mandible retains lacinia mobilis.

### Family Amphisopidae

Body sub-cylindrical, or sub-depressed, appearing compressed;<sup>(2)</sup> head relatively short, its posterior border usually overlapped by a short first peraeon segment. Eyes, when present, prominent and many faceted. Peraeon segments deeper than long; pleon segments deep. Telson not, or scarcely, produced into terminal projection. Both mandibles with pars incisiva and lacinia mobilis. Maxillula with numerous setospines on apex of proximal endite; coxae of peraeopods generally fused with pleura, basis of hinder peraeopoda usually well-expanded.

All known members of the sub-order are aquatic and in general are restricted to cold fresh water, but some members of this family are unusual. *Phreatomerus latipes* seems to be able to thrive in the steaming hot water issuing from deep artesian bores, while *Phreatoicopsis terricola* is stated to live in shallow burrows. Neither Spencer and Hall nor Raff has made any reference to the habits of this

<sup>(1)</sup> Except two subterranean genera.

<sup>(2)</sup> Except *Phreatomerus*.



latter animal, but it has been found that specimens kept under observation over several months in the laboratory would frequently come to the surface and creep over the surface of the wet soil. They appear to be strongly photophobic (their eyes apparently becoming luminous when strongly lighted) and probably under natural conditions leave their burrows only at dusk, presumably to feed. They are probably gregarious and when newly taken are often heavily infested with *Temnocephala*. *Mesamphisopus* spp. alone are certainly known to be capable of aestivation, tiding over summer aridity buried in the muddy floor of dried water holes; it is probable that *Paramphisopus* spp. may also occasionally pass through a dormant period.

Members of this family range from tropical North Australia to the temperate South-West, from the Central arid area to regions where conditions approach sub-alpine in South Africa, Victoria, and Tasmania. A blind and wholly subterranean species occurs in the Darling Range of West Australia, and semi-terrestrial burrowing forms in the Grampians and the wet Beech Forest of the Otways and the still wetter West Coast region of Tasmania.

With so wide a range and a marked diversity of habitat, it is scarcely surprising that a satisfactory diagnosis, which shall embrace them all, is not easy to formulate, nor that many members transgress its limits in one particular or another.

#### ANALYTICAL KEY TO GENERA OF FAMILY AMPHISOPIDAE (EXCEPT PROTAMPHISOPUS)

##### A. Pleopods with coupling hooks.

B. Antennule short; second pleopod modified in the ♂; penial stylet short and cylindrical, armed terminally.

C. Eyes prominent, uropod with simple spine on peduncle beneath rami; terminal spines on rami movable

*Mesamphisopus*

C<sup>1</sup>. Eyes absent; a group of short, toothed terminal spines beneath rami of uropods, terminal spine on rami fixed

*Hyperoedesipus*

B<sup>1</sup>. Antennule long, filiform; eyes large, prominent; both first and second pleopods modified in male; penial stylet large, tapering, unarmed; terminal spine on rami of uropods movable.

C. Body subcylindrical, basis expanded only on hinder peraeopods.

D. Telson convex terminally. Spine beneath rami of uropod simple; fourth peraeopod not sexually modified

*Paramphisopus*

D<sup>1</sup>. Telson emarginate. Spine beneath rami of uropod toothed; fourth peraeopod sexually modified

*Amphisopus*

C<sup>1</sup>. Body depressed; basis, ischium, merus expanded on all peraeopods; terminal spine beneath rami of uropods simple; telson incised

*Phreatomeris*

##### A<sup>1</sup>. Pleopods without coupling hooks.

B. Eyes present.

C. Eyes prominent, large; penial stylet long, cylindrical, armed terminally; basis ischium and merus expanded on all peraeopods, spine beneath rami of uropods simple; terminal spine on rami movable

*Eophreatoicus*

C<sup>1</sup>. Eyes small, typhlosole well developed; strong disto-mesial process on peduncle of uropod.

D. Typhlosole a double scroll-like structure, penial stylet large, tapering, unarmed.

E. Hinder peraeopods with bases strongly expanded, spine beneath insertion of rami of uropods toothed, terminal spine on rami movable

*Synamphisopus*

E<sup>1</sup>. Hinder peraeopods with basis almost cylindrical, spine beneath insertion of rami of uropod stout, simple; terminal spine on rami fused, immovable

*Phreatoicopsis*

D<sup>1</sup>. Typhlosole, circular in section, penial stylet long, cylindrical, armed; hinder peraeopods with basis moderately expanded, spine beneath insertion of rami of uropods toothed, terminal spines on rami fixed immovable

*Uramphisopus*

B<sup>1</sup>. Eyes wanting, penial stylet short, tapering, unarmed.

C. First pleopod with plumose setae on both lamellae, epipodite on last three pleopods

*Hypsimeetopus*

C<sup>1</sup>. Plumose setae absent from endopodites of pleopods and rare or absent from outer lamella; epipodites wanting

*Phreatoicoides*

Twelve genera are recognized, five of which are new.

Until 1926 all but four of the known Phreatoicids had been assigned to the genus *Phreatoicus*, which constituted a very mixed assemblage. In that year three species, *latipes* Chilton, *palustris* Glauert, and *lintoni* Nicholls were removed and placed by the present writer in a new genus *Amphisopus*; in the following year Sheppard suggested the name *Phreatomerus* for the same three species. A much more thorough study of these species has, however, provided evidence of the essential distinctness of each and warrants their further separation to distinct genera.

The type species *A. lintoni* has revealed several unsuspected points of resemblance to the *Phreatoicinae*, features which are not shared by *latipes* and *palustris*. Of these three, therefore, *lintoni* can alone be retained in the genus *Amphisopus*, but with it is now associated a second and new Western Australian species '*annectens*'.

The species described by Chilton under the name *P. latipes* had been chosen by Miss Sheppard as the type of her new genus *Phreatomerus*, and, since it is no longer to be included in *Amphisopus*, should be known as *Phreatomerus latipes* (Chilton). It appears to stand more apart, perhaps, than any other Phreatoicid; its nearest affinity seems to be with *Phreatoicopsis*, and, to a rather less degree, with the West Australian species *Paramphisopus palustris* (Glauert). But, alone amongst the Phreatoicids, it exhibits conspicuously a condition that can be justly described as 'depressed' (actually all the other Amphisopine forms are sub-depressed). There can, however, be little question but that this is a condition derived altogether independently from that of other Isopodan orders.

*P. palustris* (Glauert) occupies a less extreme position than *P. latipes*, and has its closest affinities with *Amphisopus*, but possesses several characters linking it with the South African species. For its reception is proposed the genus *Paramphisopus* and with it is included a second, small West Australian form from the Darling Range, here described under the specific name *montanus*.

For a species taken from a pool in the creek beneath 'Fish Falls' in the Victorian Grampians, there is instituted a new genus *Synamphisopus*, almost intermediate between *Amphisopus* and *Phreatoicopsis*, but showing affinities, also, with the New Zealand and South African forms. It is represented only by a single species which had been named, in manuscript, after its discoverer, Dr. Tillyard, who took it in 1929. The publication of the description of this (and other new species) was withheld until this present paper should be complete, but in the meantime the species was recorded by Sheard (1936) under the name *Amphisopus ambiguus*. It is of interest that from this same region a semi-terrestrial form had already been recorded (Raff, 1912) and assigned to *Phreatoicopsis terricola* with which this freshwater species has very much in common, and to which—the largest of living Phreatoicids—it approximates, also, most nearly in size.

The South African species were, by Miss Sheppard's definition of *Phreatoicus* Chilton, clearly excluded from that genus, since, as Barnard (1914, p. 236) had noted, all the coxae are fused with the pleura of their respective segments, whereas Miss Sheppard defines *Phreatoicus* as having the second to seventh coxae free.

Actually, however, the African forms are, not only in this but in almost every other respect, Amphisopine rather than Phreatoicine. For *P. capensis* Barnard and its two allied forms, *abbreviatus* and *depressus* (which are here raised to the rank of species) is now proposed the new generic name *Mesamphisopus*.

The necessity for the institution of a new genus (*Protamphisopus*) for the Triassic fossil species is discussed at a later stage, but there can be little doubt that the species *wianamattensis* would have been recorded as of the Amphisopine type (had that then been recognized) rather than as 'similar in general appearance to *P. australis*'.

A species from the Great Lake, Tasmania (probably a burrower) approaches *Phreatoicopsis* and *Synamphisopus*, and is included under the name *Uramphisopus pearsoni*.

Another Amphisopine genus is the monotypic *Hyperoedesipus*. This, notwithstanding Miss Sheppard's judgment that it must be regarded merely as synonymous with *Phreatoicoides*, likewise proves, when re-examined, to be in nearly all particulars Amphisopine. It is undoubtedly phyletically distinct from *Phreatoicoides* and will retain, therefore, its original generic designation, for, as is shown in the sequel, it owes most of its resemblance to that genus simply to parallel modifications in adaptation to a similar (subterranean and aquatic) mode of life. The study of a second species of *Phreatoicoides* found in the isolated ranges of Western Tasmania, and a third from the Otway Forest has established the fact that characters dismissed by Miss Sheppard as trivial actually have generic significance.

*Hysimetopus* may be Amphisopine. Its description is, however, not very complete, many important characters not having been mentioned by Sayce. Since but a single specimen, beside the type, remains in the Collection of the Melbourne Museum and permission to dissect this was denied, the position of this genus must remain somewhat uncertain,<sup>(1)</sup> but it seems probable that it may be the link between *Phreatoicoides* and the *Phreatoicopsine* forms.

In *Phreatoicoides* we have several resemblances to *Hyperoedesipus*, but, as noted above, these seem to be the result of convergent evolution and not evidence of near relationship; in any case, reduction has gone much further in *Phreatoicoides* than in any other *Phreatoicid*. Certain of its features suggest, however, a kinship with *Hysimetopus*, which is, only after considerable hesitation, here assigned to this family; as a consequence, the genus *Phreatoicoides*, which seems to have been derived from it, is also placed in the Amphisopidae.

As suggested by the key, these genera fall into four groups for each of which the rank of sub-family is suggested. If *Phreatoicoides* and *Hysimetopus* are included in the Amphisopidae they would constitute a fifth sub-family.

The family Amphisopidae, therefore, has been sub-divided as follows:—

Sub-family I.—MESAMPHISOPINAE

Genus—*Mesamphisopus*

Genus—*Hyperoedesipus*

Sub-family II.—AMPHISOPINAE

Genus—*Paramphisopus*

Genus—*Amphisopus*

Sub-family III.—PHREATOMERINAE

Genus—*Phreatomerus*

Sub-family IV.—PHREATOICOPSINAE

Genus—*Synamphisopus*

Genus—*Eophreatoicus*

Genus—*Protamphisopus*

Genus—*Phreatoicopsis*

Genus—*Uramphisopus*

(<sup>1</sup>) Three protracted but unsuccessful attempts have been made (in 1928, 1929, and 1939) to re-discover this species.

## Sub-family V.—HYPSIMETOPINAE

Genus—*Hypsimetopus*Genus—*Phreatoicoides*

## Sub-family I. MESAMPHISOPINAE

Small forms, sub-alpine or subterranean; body sub-depressed and scaly, in *Hyperoedesipus* vermiform; head with well-marked cervical groove; eyes either small, but prominent, with few ocelli, or absent; first peraeon segment free, telsonic apex scarcely produced. Antennule short; antenna long; mandible forwardly placed; coxae of peraeopods fused with their related segments; bases of hinder peraeopods little expanded; vestige of oostegites on fifth peraeon segment. Fourth peraeopod slightly sexually modified. All pleopods with plumose setae, sympodites with entangling setae and, in the first three pleopods at least, with coupling hooks as well; penial stylet incompletely free from lamella of endopodite, armed with terminal setae; rami of uropods lamellar, the ends truncated and armed with stout, movable spines (except *Hyperoedesipus*). Brood-pouch with relatively few embryos.

The inclusion of the eyeless and specialized subterranean *Hyperoedesipus* deprives this definition of some of its precision. The retention in all the pleopods of *Mesamphisopus* of an endopodite bearing plumose setae is highly distinctive, but this feature is lost in *Hyperoedesipus*, although that form is unique among subterranean species in preserving a primitive, heavily plumose, condition of its exopodite; *Mesamphisopus*, too, retains the free terminal spines (or second joints) on the uropodal rami, whereas in *Hyperoedesipus* fusion, complete or partial, has already taken place at this point. The occurrence of the more typical Amphisopine feature of a large simple spine at the end of the peduncle of the uropod in *Mesamphisopus* is not a characteristic of *Hyperoedesipus*.

**Mesamphisopus, gen. n.**

Body robust, markedly scaly; sub-depressed (sub-cylindrical), fusiform, length less than six times greatest breadth. Head short, with sub-ocular incisure, with a well-developed cervical groove rising from the ventro-lateral border, with a posterior process behind mandible; eyes moderately prominent, though small and with few ocelli. Peraeon much wider than deep; first peraeon segment free from head; pleon relatively long; pleura well developed; tailpiece tapers uniformly to a short projection which has a small flattened postero-ventral surface, and is armed with three pairs of movable spines, with one stout, sub-marginal spine laterally on the telsonic pleuron.

Antennule short, flagellum with few joints; antenna long. Both mandibles bear a lacinia mobilis; maxillulae with numerous (up to six) setospines on apex of proximal endite. Gnathopod not particularly strong, with an oblique palm extending practically along entire posterior border of propod, dactyl moderately long with denticulate inner border. The modification of fourth peraeopod in the male seems to involve the last three joints; brood lamellae are developed on first to fifth peraeon segments. The first three pairs, at least, of the pleopods are furnished with coupling hooks, endopodites of all the pleopods retaining a partial fringe of plumose setae; penial stylet of male curved only at its apex and but partly free from the related endopodite, with well-developed armature of stout setae. In the uropod the peduncle is short, produced at inner distal end and with simple terminal spine, inner ramus long, both rami with terminal spines freely movable. Three species known.

Genotype. *Mesamphisopus capensis* (Barnard).

Like *Synamphisopus*, this genus occupies a nearly central position within the sub-order. In many of its characters, it is Amphisopine, but in others (some of which are probably primitive) it shows affinity with the Phreatoicidae. The smallness of the eye, with few ocelli, is probably without phyletic significance, reduction of the eye having seemingly occurred many times in the Phreatoicoidea.

In the retention of a fifth pair of brood lamella, *Mesamphisopus* and *Hyperoedesipus* are peculiar in this sub-order but in that oostegites are borne on the fifth peraeon segment, it resembles the condition in the *Apseudidae* and some *Cymothoidea* and *Oniscoidea*. In both *capensis* and *abbreviatus* the fifth pair of lamellae, though free, are small and probably not functional; the oviduct appears to open just internal to its base. In *Hyperoedesipus*, it is still smaller and in *Synamphisopus*, the lamella persists only as a flattened plate firmly adherent to its related sternite and the oviduct apparently perforates it. In other genera, it seems to have disappeared entirely. In the possession of plumose setae upon the endopodite of the pleopods, it is most nearly approached by the surface-living New Zealand forms and again recalls the condition of the *Apseudidae*; but it is more primitive than in any other living Phreatoicid, since the setose (natatory) condition of this lamella is retained on all five pleopods; in *Notamphisopus* and *Hypsimetopus* only the first pleopod retains this condition, and in those genera the coupling hooks are wanting.

In the peculiar modification of the fourth peraeopod in the male, *Mesamphisopus* seems most nearly to resemble *Amphisopus* and *Eophreatoicus*. The markedly scaly condition of the surface of the body is seen in *Eophreatoicus* and *Phreatoicopsis* and in a lesser degree in *Amphisopus*, *Synamphisopus*, and *M. tasmaniae*. Coupling hooks on the pleopods are restricted to the *Amphisopinae* and *Mesamphisopinae*.

The retention, in some species of this genus, of numerous setospines on the apex of the proximal endite of the maxillula is an Amphisopine character, this condition being found in *Amphisopus*, *Paramphisopus*, *Phreatomerus*, *Eophreatoicus*, *Phreatoicopsis*, and, also, in *Phreatoicus* (s.s.);<sup>(1)</sup> and the retention of a *lacinia mobilis* on right as well as on left mandible characterizes all of those forms, with the exception of *P. typicus*.

The bluntly-ending rami of the uropods with their terminal armature of one, or more, freely movable spines is again a feature characteristic of the Amphisopinae, persisting otherwise only in *Eophreatoicus* and *Synamphisopus*. The simple (non-toothed) condition of the terminal spine on the peduncle, at the base of the rami, recurs in the genera *Paramphisopus*, *Phreatomerus*, *Eophreatoicus*, *Phreatoicopsis*, and *Phreatoicus* (s.s.). On the other hand, the cylindrical penial stylet of *Mesamphisopus* has a strong resemblance to the condition found in *Hyperoedesipus*, *Eophreatoicus*, and, in a lesser degree, in *Notamphisopus*. In both *Mesamphisopus* and *Hyperoedesipus*, the actual stylet is short and its base long, and the terminal armature reduced; whereas in *Eophreatoicus* it is the base that is short and the freely movable stylet long, and the terminal armature complete, but otherwise the structures are closely comparable and differ from that of other Phreatoicids.

But the retention on the head of a well-developed cervical groove, of a short club-shaped antennule with few joints, and, in the peraeon, of the freedom of the first segment, are features shared with *Hyperoedesipus*, but characteristic of the *Phreatoicidae*.

(<sup>1</sup>) And as a rare variation in *Notamphisopus* and *Mesacanthotelson*.

**Mesamphisopus capensis (Barnard)**

(Figs 6, 7)

Barnard, 1914, p. 223, pls. 23 and 24; 1927, p. 139, figs 1, 3-6 (*Phreatoicus capensis*).  
Sheppard, 1926, p. 109 (*Phreatoicus capensis*).

The original description published by Barnard appeared at a time when there were known but few Phreatoicids, all from South-Eastern Australasia and New Zealand. The account was somewhat brief, comparison was made principally with *P. australis*, and attention was not drawn to several characters which subsequent work has shown to have significance. Later, Miss Sheppard in her 'Revision of the Phreatoicidae' dealt with the South African species somewhat superficially. Although specimens were available for study, her account adds nothing to our knowledge and seems merely an inadequate summary of Barnard's description, some of the omissions being unfortunate. Moreover, in view of the importance that Miss Sheppard attached to the fusion or freedom of the coxa of the peraeopods, one, at least, seems inexplicable, for in the 'Revision', the free condition of the hinder six of the coxae is made a generic character for *Phreatoicus*. Barnard had stated quite positively (1914, p. 236) that the coxae of all the peraeopods were fused with their related segments ('epimera'). Yet, without comment, *capensis* is included in that genus, although there can be little doubt that Barnard's statement is substantially correct.<sup>(1)</sup>

In addition to supplying, generously, preserved material of the three South African species, Dr. Barnard went to considerable trouble to provide abundant living material of *capensis*, when the writer was passing through Cape Town in Mid-winter, 1936. With constant attention these survived the voyage to West Australia and lived under laboratory conditions until the end of the year, but in January, 1937, after a short absence from Perth, all were found to have died. Just a year later, Dr. Barnard sent another consignment, but unhappily these succumbed on the journey. For all of this help grateful acknowledgment is made.

A number of observations had been made, however, upon the fresh material and a very detailed study confirmed the view that *capensis* was not, as Barnard believed (1927, pp. 155 and 158), most nearly related to *australis*, but was, indeed, generically distinct and to be classed, on the sum-total of its characters, with the Amphisopine rather than the Phreatoicine members of the sub-order. This view had been put forward earlier (in 1926), but the summary (published in 1928) omits the analysis on which this conclusion was based. There seems little room for doubt that *capensis* retains a large number of primitive features and thus shows affinities with several different, and to-day, widely scattered, groups of Phreatoicids. A satisfactory discussion of this matter is possible, however, only in the light of a much fuller description.

*Body* stout, sub-depressed, length less than six times the greatest width. In the peraeon, the width is little less than twice the depth, so that a transverse section through this region is markedly different from that of some Phreatoicine forms, but even so, the flattening is much less extreme than that found in the Amphisopine form, *Phreatomerus latipes*. Sculpturing of the head and peraeon is scarcely developed, but the surface, examined under a fairly high magnification, is marked in such a way as to suggest a covering of closely adherent and but slightly overlapping scales, the free edge of each scale being produced into a short fringe of stiff setules. There are, also, short and sparsely scattered setae

(1) There may be a slight mobility in the three hindmost coxae

The head (fig. 6, 2d, 2s) is as deep as wide, and rather wider than long, its length being less than the combined length of the first and second pereaeon segments; its anterior border is emarginate but bulges immediately in front of the eyes. From the sub-ocular incisure, the front slopes upward, the slope being much less

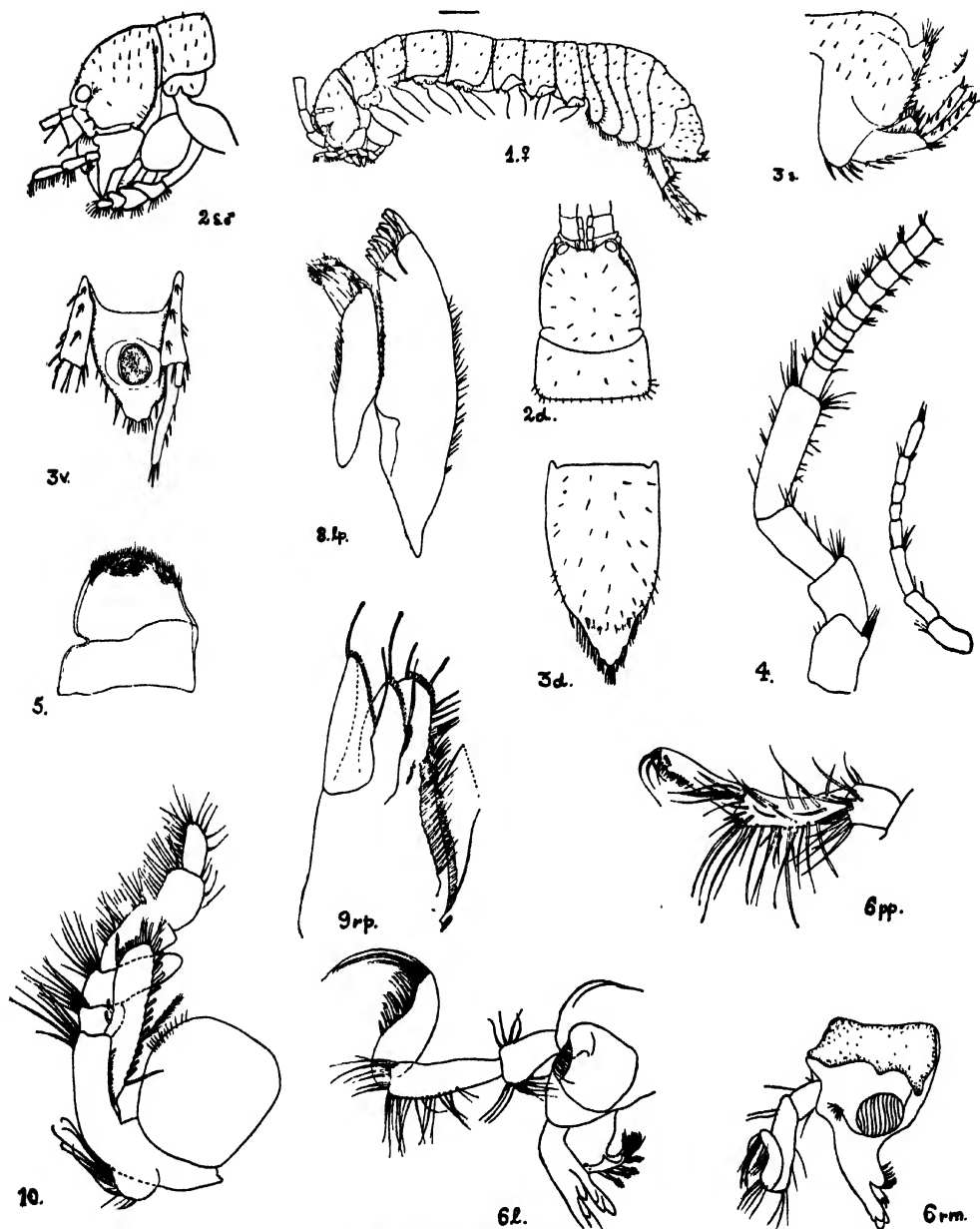


FIG. 6.—*Mesamphisopus capensis* (Barnard).

steep in the male. Starting from behind the eye, there is a well-marked genal groove, but, below the incisure, the sub-ocular segment is not well defined. The ventro-lateral border of the head makes a very uneven line with the mandibular articulation (fig. 6, 2s) and is produced downwardly behind the mandible into a short 'posterior process'. The cervical groove is well marked and springs from the ventral border demarcating a maxilliped segment which is incomplete dorsally but unusually wide below. The hinder edge of the groove is raised into a distinct ridge, behind which the postero-lateral surface of the head is partly exposed.

The *peraeon*. The first segment is long, practically half the length of the head and is slightly shorter than the second, and is unusual in that it is not shortest in the mid-dorsal line. There would seem to be considerable variation here, for Barnard notes that the second, third, and fourth segments are sub-equal and 'nearly as long as' the first. In the specimens examined, the third and fourth segments appear to be a little longer than any of the others, the terga only about as deep as long, the ventral (sternal) region not being hidden, in side view, in the male; in the female, these segments are, relatively, a little deeper; the fifth and sixth segments are sub-equal, the seventh considerably shorter and deeper, its depth almost twice its length; the first segment is scarcely forwardly produced, while the second to seventh are all downwardly produced in front of the related coxa, and the ventro-posterior corners are rounded. The hinder borders of the *peraeon* segments are fringed with short setae.

The length of the *pleon* appears to vary considerably as compared with that of cephalo-peraeon, according to the state of contraction of the latter. It differs from most other species in the abruptness of its deepening, the first *pleon* segment being once and a half as deep as the last *peraeon* segment and nearly twice and a half as deep as the second *peraeon* segment. The second, third, and fourth show the usual progressive increase in length but little greater depth, while the fifth is equal to the combined length of the third and fourth and rather longer than the tailpiece. In all of the five *pleon* segments, the rounded lower margins are armed with long setae, this fringe being continued up the posterior margin of the *pleura* for some distance. The fifth *pleuron* meets its segment behind in a deep rounded notch.

The tailpiece (fig. 6, 3) is helmet-like in side view; seen from above, it appears as a truncated cone; from below it is, as figured by Barnard, more nearly sub-triangular, the terminal projection being strongly marked off from the rest of the piece. In profile the telson is strongly convex, but its dorsal surface is distinctly concave just anterior to the slightly uptilted apex. The telsonic *pleura*, confluent with the apex, bear three pairs of freely movable spines, the last pair lateral and terminal. Below, there are slender widely-spaced setae. Only a short suture indicates the junction of telson and sixth *pleon* segment, this being unarmed, except for a row of microscopic spinules (cf. *Eophreatoicus*).

Anterior to the uropod, the *pleuron* of the sixth segment is narrow, its anterior border straight and nearly vertical, its lower rounded margin bearing but three of four spines,<sup>(1)</sup> the last exceptionally stout. The anal opening is presented ventrally.

The *antennule* agrees quite closely with Barnard's description, except that there may be variation, in the flagellum, from three or more longish joints to six shorter ones, with the last usually minute, the fourth and fifth sub-equal and the first longer than the second or third. These are probably differences due to growth,

(<sup>1</sup>) The comparative paucity of spines in this region is paralleled in *Eophreatoicus*, *Amphisopus*, and some New Zealand species.



but the appendage differs notably from both *abbreviatus* and *depressus* in the slenderness of the peduncle of this appendage. There is normally a terminal tuft of olfactory cylinders.

The *antenna*, too, shows slight variation from the description given by Barnard (for the male), the second and third joints of peduncle being practically sub-equal, the entire appendage rather more than half the length of the body. In the female, the flagellum is about twice the length of the peduncle and has approximately twenty joints. It is noticeably long and slender as compared with those of *abbreviatus* and *depressus*.

Both the *labrum* (fig. 6, 5) and epistome show to a very marked degree the asymmetry which characterizes this region in this family.

*Mandibles*. These (fig. 6, 6) are stout; they articulate by a long, uneven hinge with the ventro-lateral border of the head, the hinder end abutting against the antero-ventral part of the maxilliped segment but not, apparently, developing the usual hollow acetabular surface; there is present an unusually extensive opening mesially for the adductor muscle. At the anterior end, the large fulcral process is almost conical and moves upon the sub-ocular lobe and against the outer border of the upper lip. On the right side, the mandible seems rather shorter and stouter than the left, there appears to be a trace of a fourth tooth on the cutting edge, the lacinia mobilis is much slighter, the spine row smaller, differently-shaped, and with a number of free setae springing from its shaft; the molars exhibit the usual difference in shape and disposition, the palp seems rather less setose.<sup>(1)</sup> In the left mandible the tooth-bearing part is long and strongly bent, ending in four stout teeth; the lacinia mobilis is, also, strong and bears but three heavily chitinated teeth. The spine row is raised on a high base and the spines, well separated distally, are closer and more slender as the free end is neared. The palp (fig. 6, 6l, 6pp) is well developed and has a moderately long first joint with a number of long setae sub-terminally, the second joint nearly twice as long with a fringe of long setae extending almost the entire length of its anterior border and a terminal circlet, while the third, little shorter than the second, has the characteristic (sub-crescentic) shape, with fine setae along most of its concave edge. The apical setae being increasingly long, the terminal setae are simple and as long as the joint itself.

The *lower lip* calls for little comment. It resembles that of *Amphisopus* rather than *Phreatoicus* and among its terminal setae appear to be some setospines.

The *maxillula* (fig. 6, 8lp) appears to differ rather markedly from the condition figured by Barnard (1917, pl. 23, fig. mx. 1.) where the two endites are shown almost equally wide. In the several specimens examined, the inner (proximal) endite is much smaller than the outer; its apex is obliquely truncated rather than rounded and the setospines, four or five in number, are rather widely separated, the innermost rising from the mesial border of the endite. They are flanked by a parallel row of three,<sup>(2)</sup> which are feebly ciliated. The outer (distal) endite is stouter, longer, slightly bent, and narrowed distally. It bears the usual double, partly triple, row of denticulate spines (12-14). Upon its posterior face, there are two feathered setae.

The *maxilla* (fig. 6, 9rp.) is relatively short and wide. Its proximal endite is clearly marked into two regions; (i) a proximal-mesial with the typical anterior row of filtratory setae backed by the posterior (sub-marginal) rank of stiff pectinate

(<sup>1</sup>) In the armature of the mandibular palp, this species recalls the condition found in some species of *Mysis* and *Apseudes*.

(<sup>2</sup>) Sometimes only two, but four in one specimen.

setae; and (ii) the distal part meeting the proximal at a sharp angle, the junction, in some cases, seeming to be marked by a short cleft. It is armed with the characteristic brush of mixed pectinate, plumose and simple setae. The inner of the distal endites is narrow and does not extend so far distally as the outer which arises at a different level and is short and unusually wide. Both are similarly armed along an oblique distal edge with long denticulate setae or spines.

The *Maxilliped* (fig. 6, 10). The coxa is short, with its epipodite sub-quadrangular with rounded corners, its distal margin with a sparse fringe of long setae; the basis is long and is produced into a moderately long endite, the antero-mesial edge fringed along almost its entire length with the characteristic brush setae, about twenty in number, these passing into the distal armature of pectinate setae. There are two long coupling hooks on one maxilliped and three on the other. The whole appendage is fringed with numerous long setae, the propod is expanded, the dactyl broadly ovate. In the female, the coxal lobes of the maxilliped are particularly well developed. They are broad-based and project back, practically at right angles to the coxae, to lie entirely within the brood-pouch almost vertically, fringed along their whole free margin with long curved setae. When the fully developed oostegites of the gnathopods are in position (fig. 7, 10v), these coxal lobes appear to close the median gap between the small anterior lobes of the first oostegites. It seems quite unlikely that they can play any part in the respiratory movement of water within the brood-pouch, but they form a sieve-like barrier at the anterior opening of the brood-pouch; they probably prevent the accidental escape of eggs, although they may be concerned, also, with the shifting and rearrangement of the developing eggs.

*Peraeopods.* The coxae of the anterior group of legs appear to be completely fused with their related segments, the actual boundary of the coxa being, in the case of the gnathopod, largely obliterated. In the hinder group, the coxa of the fifth leg is large and triangular and produced posteriorly, but in the two succeeding legs, the coxae are flattened and little produced; they appear, like those of the anterior group, to be united with their segments. All the coxae bear a few setae. In the female, the peraeopods generally are slender and setose.

The *gnathopod* (fig. 7, 11♀) is short and the joints relatively stout; the ischium about two-thirds of the length of the basis, merus greatly produced antero-distally, the propod as long as the basis; its palm, little marked off from the posterior margin, swells proximally, but is slightly concave towards the dactyl, bearing about eight slender curved spines and numerous setae; dactyl stout and straight, almost as long as propod, its inner border denticulate along much of its length.

The first oostegite (fig. 7, 10v) is subdivided into a smaller anterior (and nearly vertical) lobe and a much larger posterior lobe forming the antero-ventral part of the marsupium. The anterior plate is fringed with long setae and is applied to the convex surface of coxa and basis of maxilliped. The following oostegites (fig. 7, 12(2)) are simple and very large, as long as the related legs, and bear a few fringing setae. The joints of the second to fourth legs are almost linear, but the merus is still seen to be a little produced. On the fifth leg, all the joints, except the basis, are linear and much more nearly sub-equal, the dactyl having the terminal claw movable. Internal to the coxa of the fifth leg, there is found a quite large vestige of a brood lamella as a sub-triangular membranous flap (fig. 7, *pr.v.*) backwardly directed and overlying the oviducal aperture.

In the male, the gnathopod (fig. 7, 11♂h) is much stouter, there is a notable development of the propod, which is a thickened sub-oval joint nearly once and a

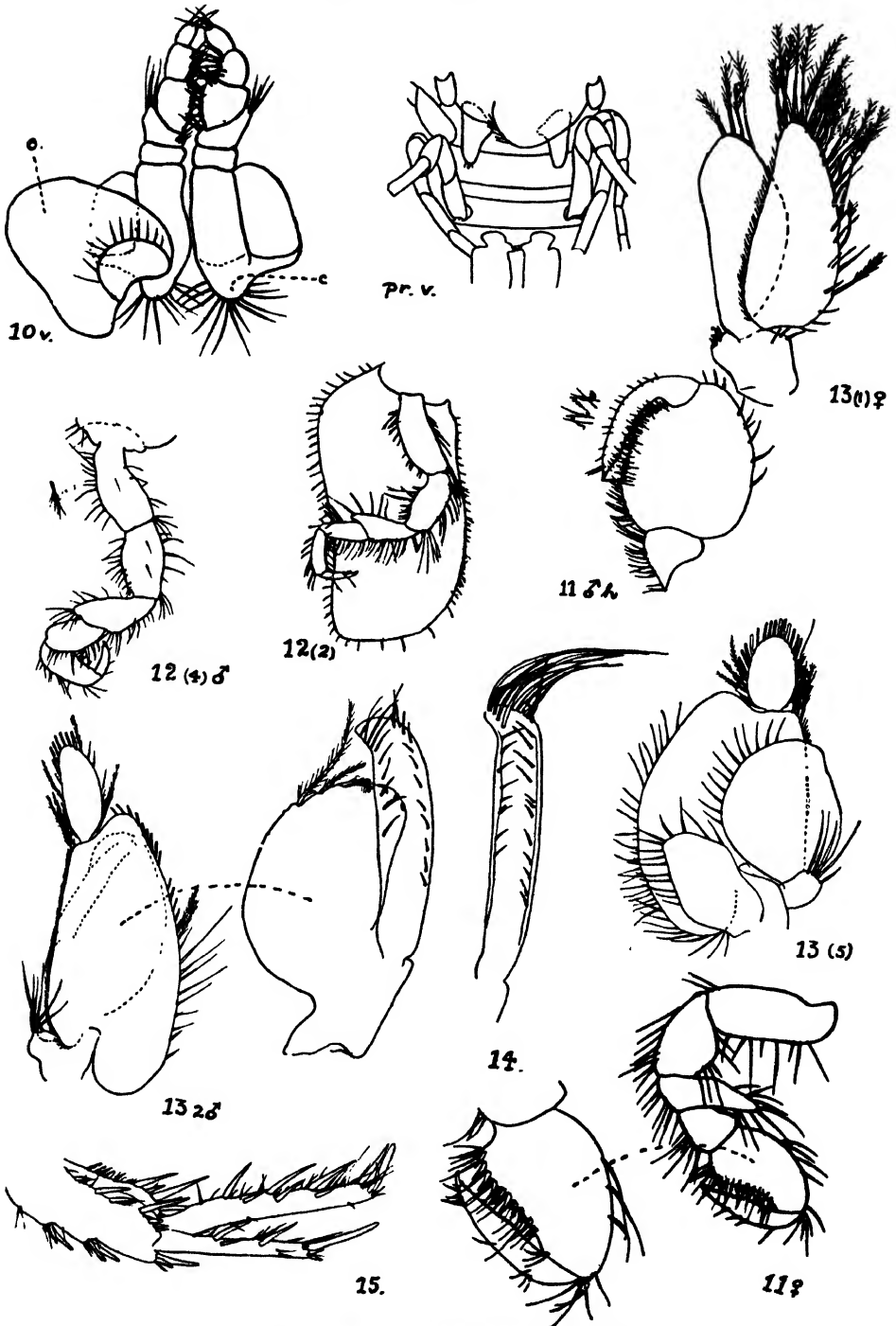


FIG. 7.—*Mesamphisopus capensis* (Barnard).

half the length of the basis. This appendage probably retains the primitive sub-chelate condition, the oblique palm not being marked off, except for the presence of dentate spines, from the general hinder border of the joint; the dactyl stout (relatively much shorter than in the female) sharply bent near its origin and thereafter nearly straight; its inner margin minutely denticulate for the distal third of its length. The condition of this hand approaches nearly to that found in *Eophreaticoicus*.

In the second to fourth peraeopods the merus is moderately expanded anteriorly (again reminiscent of the condition in *Eophreaticoicus*), while in the fourth peraeopod the armature of carpus and propod (fig. 7, 12(4)) suggests that, as in *Amphisopus*, all three terminal joints may be concerned in the sexual modification of this appendage as a prehensile limb. The anterior border of the basis is moderately setose, one or two setae being multi-ciliate and probably sensory. Of the three legs of the hinder group, the fifth is short, the sixth and seventh considerably longer, armed with abundant setae and many spinules; upon the seventh the basis is slightly expanded posteriorly into a thin plate, the maximum width of the joint being about two-thirds of its length. There is noticeable a sub-equality in the length of the several joints of these legs.

From the coxae of the seventh peraeopods spring the small penes, short, bluntly ending, little curved and armed mesially with a few setae. The two are quite widely separated and the condition suggests that this is almost certainly an early phase in the evolution of this structure. In one female (a specimen in the collection of the South Australian Museum), this structure is present, co-existent with brood lamellae.

*Pleopods.* Barnard's statement that the first pleopod has both lamellae lanceolate in shape and equal in size is true of the male. In the female (fig. 7, 13(1)♀), the apex of the endopodite is rather more bluntly rounded. In both sexes, both rami carry plumose setae, but these are more numerous in the male, where in the exopodite, they may extend along the distal fourth of the mesial border (about eight) around the apex as far as the proximo-lateral curve. On this margin, there are about twenty-five plumose setae mixed with many simple setae so that the lamella appears almost as setose as in the first pleopod of *N. littoralis*. In the endopodite, plumose setae are restricted to the apex and lateral border and are about twenty-two all told, which, except for *N. littoralis*, is the most setose of any endopodite in the Phreatoicoidea. In the female only about four or five are retained on this inner lamella and these are latero-distal. The sympodite bears from four to six coupling hooks in both sexes, these springing from the mesial and apical part of the widely-rounded mesial coupling lobe, the hooks being minutely barbed. The lateral border of the sympodite has about eight or ten scattered setae (fewer in female), some being sub-marginal in position.

The second pleopod, in the male (fig. 7, 13(2)) is stouter and longer than the first by the length of the distal exopodite lobe, and both lamellae are wider. The endopodite is ovate (its proximal end being narrow), just extending to the distal exopodite lobe. Its mesial border is separated for rather more than the distal half of its length into a semi-cylindrical penial stylet (fig. 7, 14); this has an open groove mesially, both free margins being set with spinules and setae; its apex bears eight or nine stout setae, and projects in a fashion unique in this sub-order, but reminiscent of that in many other Isopoda; the lateral border of the endopodite has ten or eleven stout plumose setae not all being shown in the figure. The proximal lobe of the exopodite has a fringe of stiff, short setae along its mesial border, but distally it bears three long plumose setae; half of the mesial border of the distal lobe is similarly fringed with close-set stiff setae, followed

by half a dozen long plumose setae. These continue around to the lateral border of the lobe with about sixteen plumose setae intermingled with a few sub-marginal setules. The proximal lobe has fifteen to eighteen plumose setae laterally becoming shorter as the middle of the lobe is reached; from there they are continued proximally by setae which are not plumed. This sympodite, also, has from four to six strongly-curved coupling hooks at its mesial distal angle and some seven or eight stiff setae. In the female, the endopodite is considerably shorter and bears very few (four or five) plumose setae and the sympodite but one or two coupling hooks with a few entangling setae, these being carried on a distinct lobe.

The third, fourth, and fifth pleopods are more nearly alike, each becoming a little shorter and increasingly wider, the epidodites varying in shape from ovate to oval, but differing little in size; they are armed with long simple setae. The sympodites in the male bear two or three coupling hooks (third), one or two (fourth) and none on the fifth pleopod, while the entangling setae increase progressively in number. The endopodites diminish in size from third to fifth (fig. 7, 13(5)) and there are fewer setae plumose on the hinder endopodites, although the actual number of setae increases rather than lessens.

In the female, in these hinder pleopods, the setae on the endopodites are very few (four to six) and tend to become simple; on the fifth none are plumose. Coupling hooks are wanting, as in the male, on the sympodite of the last pleopod and there is usually one only on the third and fourth, while the related entangling setae are less numerous than in the male.

The *uropods* (fig. 7, 15) are slender and the inner border of the peduncle is so greatly developed as to make the joint appear almost laminar. The peduncle appears oblong, but widens distally where its spinose inner edge is most strongly produced, and is surmounted apically by several spines, two of these being particularly stout; the outer edge is very much lower and bears several spines. The intervening surface is nearly flat, but the elevation of the inner margin gives the impression that the surface is grooved. The ventral border of the peduncle has three stout spines supported by clumps of setae and is terminated by a stout simple spine flanked by two smaller. The rami are thin, the inner so tilted that most of its breadth appears in side-view; the inner is one-third longer than the outer which itself is as long as the peduncle, a most unusual condition (cf. *M. tasmaniae*). Both are terminated by a stout movable spine (in the case of the inner ramus, this is flanked by a second equally strong); their crenate upper margins lodge three or four irregularly-spaced spines; there may be many fine setae present but these seem variable.

*Occurrence.* Under moss in a swiftly flowing stream on Table Mountain, at 3000 feet and above (Barnard, 1914, p. 233).

*Colour.* Pale grey to dark grey, the appearance being due to scattered black chromatophores on an almost colourless background.

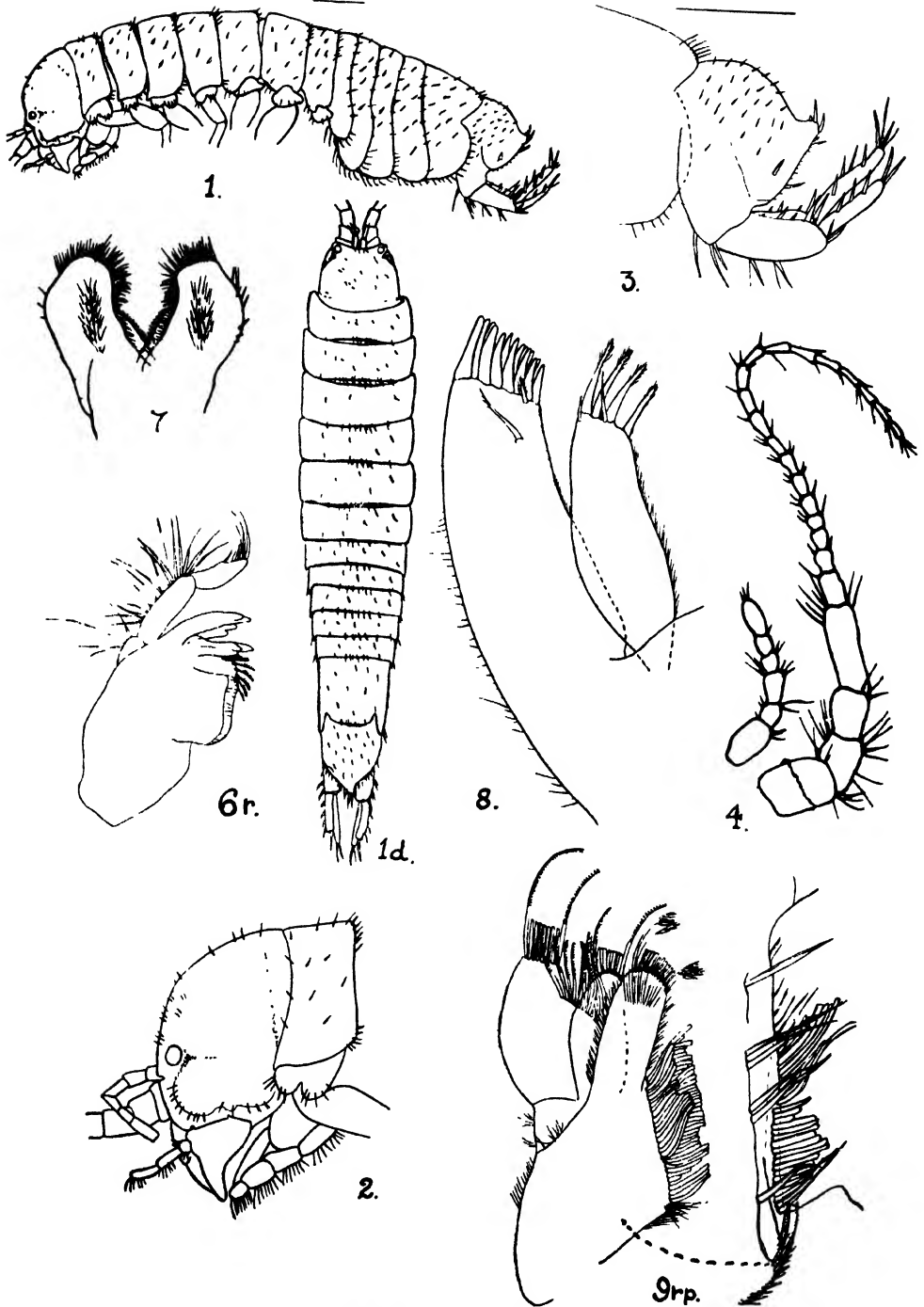
*Size.* Up to 14 mm.

### **Mesamphisopus depressus (Barnard)**

(Figs 8, 9)

Barnard, 1927, p. 157 (*Phreatoicus capensis* var. *depressus*).

The body, as seen from above (fig. 8, 1d) is fusiform, its greatest width attained in the fourth pereon segment, behind which it tapers evenly to the end of the body. The width is less than twice the depth of that segment and about one-fifth of the total length. The scattered setae which cover the body are long

FIG. 8.—*Mesamphisopus depressus* (Barnard).

and even more abundant than in *abbreviatus*. In most segments, there is an incomplete fringe along the hinder border; in the pleon, the stiff setae forming the ventral fringe are still longer and are intermingled with a series of long fine hairs.

The head (fig. 8, 2) differs somewhat in its proportions from that of *capensis*, the cervical groove appears to extend more dorsally; the clustered setae in front of, and external to, the eyes are very noticeable, both antero-ventral and ventro-lateral borders being setose. The eyes have about nine ocelli.

*Peraeon*. The first segment is relatively much shorter than in *capensis*, so that in this species the head is as long as the combined length of first and second peraeon segments but is otherwise as in *capensis*, anterior and posterior borders being parallel, and the segment scarcely extending forwardly onto the head. The second to fifth segments are sub-equal, the sixth is a trifle shorter and the seventh only one-half as long as the sixth, but distinctly deeper. The first four pleon segments are short, the fifth almost equalling the total length of the second, third, and fourth segments; the greatest depth of the pleon is about twice that of the first peraeon segment, and greater than the maximum width of the body; the tailpiece (fig. 8, 3) is a little longer than the fifth segment.

*Antennule* short (fig. 8, 4), reaching only to the end of the fourth joint of the antenna; its peduncle with second and third joints short, stout, sub-equal, but the flagellum, with three or four joints and minute apical knob, is shorter than the peduncle; where four are found, the first three are sub-equal, the fourth longer and greatly swollen. Apically is borne a cluster of setae including one or two olfactory cylinders. *Antenna* short, moderately stout; the flagellum, with twenty-four joints,<sup>(1)</sup> is about twice the length of the peduncle. The *labrum* has a deep indentation on one side only, its apical fringe of setae asymmetrically placed. *Mandibles* (fig. 8, 6), situated very far forward, fulcral process conical; left mandible, principal dentate edge with four teeth, lacinia mobilis with three, first two spines of spine row long, bifid, and denticulate; the palp short with wide joints recalling the condition seen in *Eophreaticoicus*, first joint moderately long, with a tuft of stout setae close to its base, second broadened, with numerous long and very slender setae in two rows, but the third joint has usually only one long apical seta and a few (five to six) short simple setae immediately proximal, a condition markedly reduced as compared with *capensis*, where the setae are numerous and extend the greater part of the length of the third joint.

*Labium* (fig. 8, 7). This differs little from that of other species of *Mesamphisopus*, except that the apex of the outer lobe appears truncate rather than evenly rounded and the two or three setospines appear indistinctly in the very dense setal fringe.

The *maxillula* (fig. 8, 8), shows some reduction from the condition seen in *capensis*. The proximal endite bears two simple spines and only four setospines with very few cilia, which are mostly apical. The distal endite usually retains two sub-terminal plumose setae; its apex is armed with about ten stout teeth (all but the innermost, denticulate) and one small setospine; the inner and outer borders of both endites are setose; the condition of this appendage approaches quite nearly that found in *H. plumosus*.

The *maxilla* (fig. 8, 9) is somewhat variable. In the proximal endite, the basal and distal parts are scarcely defined, the row of filter setae is well developed, but scarcely passes onto the anterior face of the endite; the row of biting setae which lies immediately posterior is more sparse and the considerable gap between

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(<sup>1</sup>) Only nineteen in specimen figured.

the end of this and the distal fringe is edged with fine hairs, and the anterior face bears a sub-terminal rank. In the specimen figured, the filtratory setae appear as a double rank! The inner of the two distal endites is little shorter than the outer. The apical fringe of all is dense, consisting of the usual cluster of mixed setae. The outermost lobe appears narrow, but this is apparently due to the folding of the plate upon itself to ensheath the middle plate. In the dense apical tuft of setae there appear to be one or two spines, much stouter and with coarse denticulation. It is difficult to be sure of this, but the appearance is much like that of this appendage in *Eophreatoicus*.

The *maxilliped* (fig. 9, 10) is very setose; the large coxa is fringed with setae and bears a rather angular epipodite, the basis is comparatively short, its endite with a long series of brush setae. All the joints are setose, the last three flattened and, in the case of carpus and propod, produced mesially. The dactyl bears several setae on its outer border in addition to a considerable mesial fringe.

The *gnathopod* is not very stout (but the specimen may have been immature); in shape and armature, the hand (fig. 9, 11) approaches the condition of the female of *Hyperoedesipus*; the dactyl, however, along much of its palmar border, is strongly denticulate.

The *fourth peracopod* is scarcely modified in the male, the propod being without recognizable palmar spines, but the carpus is strongly spined, and, in all probability, prehensility involves the distal three joints.

*Pleopods.* The first (fig. 9, 13(1)) has the rami practically equal in size and oval in shape. The exopodite has a fringe of plumose setae which is particularly dense apically. The lateral border appears to be cleft so that the fringe here is doubled. The straight mesial border of the lamella has a close fringe of short hair-like setae, the rounded apex of the endopodite has a short rank of five or six stout plumose setae, while elsewhere on its border are scattered setules. The lamellae spring by narrow bases from a sub-quadrangular sympodite; the outer border is slightly produced and bears long, lateral and apical setae; mesially a half-dozen coupling hooks project from a short rounded lobe. The surface of the sympodite is covered with setules in tufts suggestive of a development of the scaled condition.

In the second pleopod (fig. 9, 13(2)) the endopodite (en.) is short and visibly divided into a muscular basal portion and an expanded respiratory lamella, this latter with six or seven stout plumose setae around its free end; the penial stylet (figs 13 (2) and 14) is a widely open scroll-like structure with inner and outer fringe of setules or spinules lengthening towards the apex; as in *capensis*, the actual apex is slightly bent and produced. The sympodite is largely masked laterally and mesially by the proximal lobes of the exopodite, but near its distal end are two or three coupling hooks and as many entangling setae.

In the succeeding pleopods, the exopodite becomes progressively shorter and broader, the endopodite, also, changing in shape, but with its latero-distal plumose setae increasing to a maximum of nine in the fourth pleopod. In the last (fig. 9, 13(5)) the entire outer border of the endopodite is setose, the fringe consisting of a dozen stout simple setae. There is but a single coupling hook on the third and fourth sympodites, the fifth bears only long entangling setae, six or more in number.

*Uropod.* The peduncle is sub-oblong, inner border not greatly higher than the outer, both set with a few stout spines; its ventral surface bears several clusters of spines and setae. Terminally, beneath the insertion of the rami is a stout simple spine and two small spines; on the mesial edge just dorsal to these, is one short multifid spine and a short rank of setules. The inner ramus is slightly longer than the peduncle, is flattened (lamellar) and curiously bent near its base. The



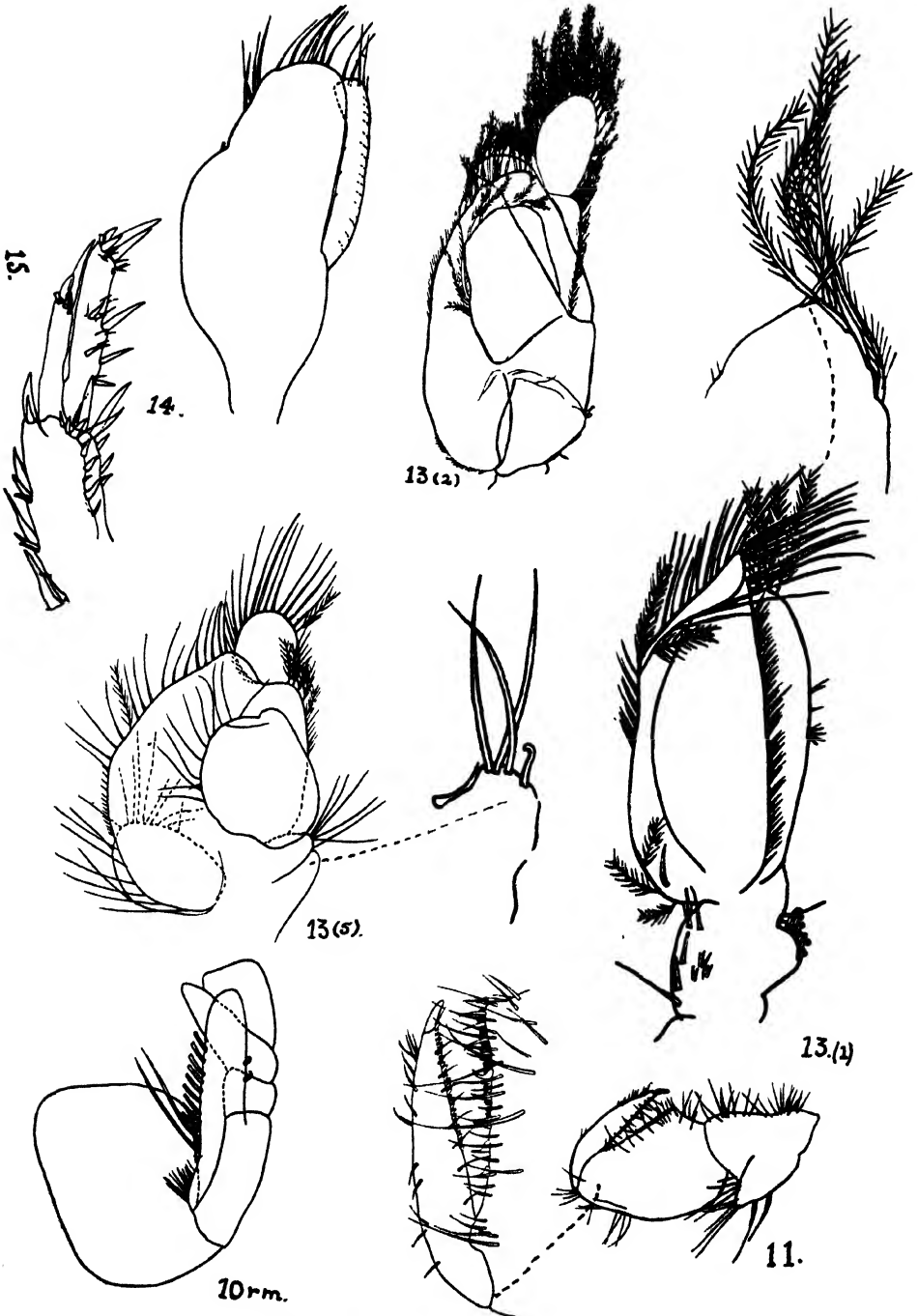


FIG. 9.—*Mesamphisopus depressus* (Barnard).

outer ramus is shorter, both are bluntly truncated terminally and armed with spines laterally and terminally, the spine on the outer ramus being long and highly suggestive of a second joint.

*Occurrence.* Near the Forest Ranger's Hut in the Steenbras Valley, Hottentots Holland Mts. (Barnard).

*Coloration.* As in *capensis*.

*Size.* Probably not reaching 10 mm.

### *Mesamphisopus abbreviatus* (Barnard)

(Figs 10, 11)

Barnard, 1927, p. 157, figs 3-6 (*Phreaticus capensis* var. *abbreviatus*)

A critical examination of Barnard's variety reveals that it differs from *capensis* in many respects and should be ranked as a distinct species. The description appended relates principally to these differences.

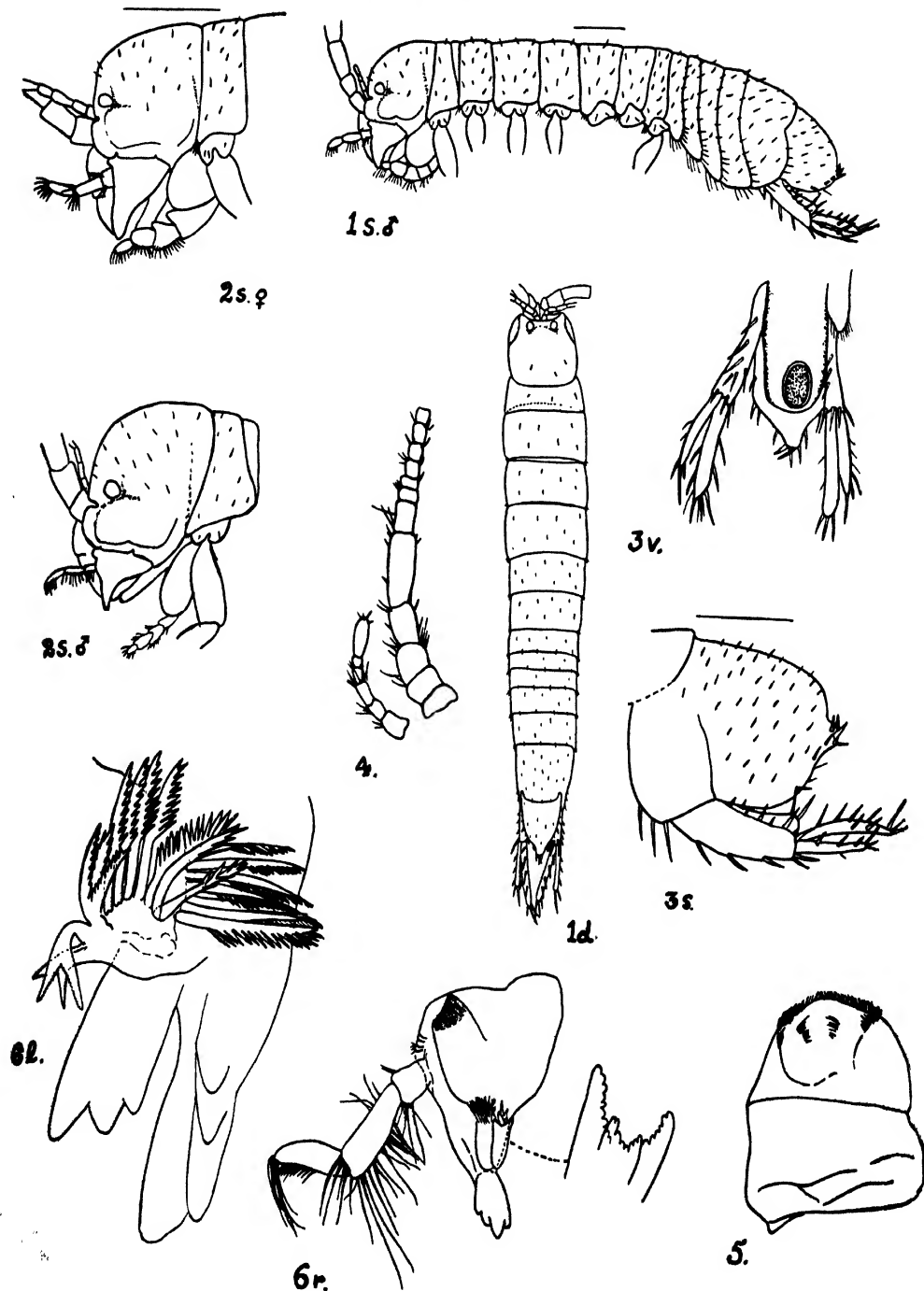
Body sub-depressed (fig. 10, 1s, 1d), in dorsal view sub-fusiform, the head being little narrower than the peraeon, whereas the pleon tapers quite considerably, the tailpiece being less than two-fifths of the width of the peraeon, which is twice the depth of that region. It is rather more setose than *capensis*.

The head (fig. 10, 2), which is longer than the combined length of the first and second peraeon segments, is a little wider than long and as deep as wide. It rises in front almost vertically from the sub-ocular incisure which is wide and shallow, its anterior border being very shallowly emarginate. The interorbital space is unusually narrow. The mandible lies very forwardly and behind its hinge articulation, the ventro-lateral border dips down steeply to be produced into an unusually long 'posterior process'; the genal groove is short, the cervical groove feebly developed. The eyes larger, relatively, than those of *capensis*, seem variable in shape, being in one specimen sub-oval with long axis antero-posterior, in a second more rounded and long axis vertical.

In the *peraeon*, the segments differ noticeably from those of *capensis*, the first is short (about one-third only of the length of the head, or two-thirds of the second peraeon segment), the third more than twice the first; fourth, fifth, and sixth segments are progressively shorter, the sixth being sub-equal to the second, the seventh shorter than, but as deep as, the first, the intervening segments being shallower. Apart from this difference in proportions, the first segment lengthens ventrally (i.e., expands antero-posteriorly) in the male, while in the female, its borders are parallel, but ventrally it is obliquely truncated. The suture of the coxa of the gnathopod with its segment is much more clearly indicated than is the case in *capensis*.

The *pleon* resembles fairly closely that of *capensis* in its proportions, but is more setose, while the pleura differ in shape, being angular at the postero-inferior corner rather than rounded below, the notch between pleuron and tergum of the fifth segment is shallow, the tailpiece ends more bluntly and is shorter (relative to the uropods) and its apex is practically not upturned.

*Antennule* (fig. 10, 4). This is very short, having in all but six joints in one specimen (male) and but five in a second specimen, of which three short joints constitute the peduncle; the flagellum, having but two joints and being even shorter than the peduncle, the terminal article longest. It is apparently the shortest antennule of any Phreaticoid at present known, although one specimen of *capensis* has been found with but six joints.

FIG. 10.—*Mesomphicopus abbreviatus* (Barnard).

The *antenna* (fig. 10, 4) comparatively short; peduncle relatively more robust than in *capensis*, fifth joint less slender, flagellum with twenty-four joints, about twice as long as peduncle.

*Labrum* and *epistome* (fig. 10, 5), asymmetrical, the unpaired notch for the mandibular palp, although indicated, is less strongly developed than in *capensis*.

The *left mandible* (fig. 10, 6) resembles rather closely that of *capensis*, but proximal to the strongly developed spine row there are a number of setae (five or six) plumed on one side only. In the right mandible (fig. 6 r.) there are four teeth on both principal cutting edge and lacinia mobilis, the latter being minutely denticulate.<sup>(1)</sup> The palps are as markedly setose as those of *capensis*.

In the *maxillula* (fig. 11, 8), the proximal endite bears four terminal spines feebly plumed with a parallel row of four simple spines. The distal endite differs from that of *capensis*, principally in that it shows no appreciable narrowing distally; there are two feathered setae on the posterior face.

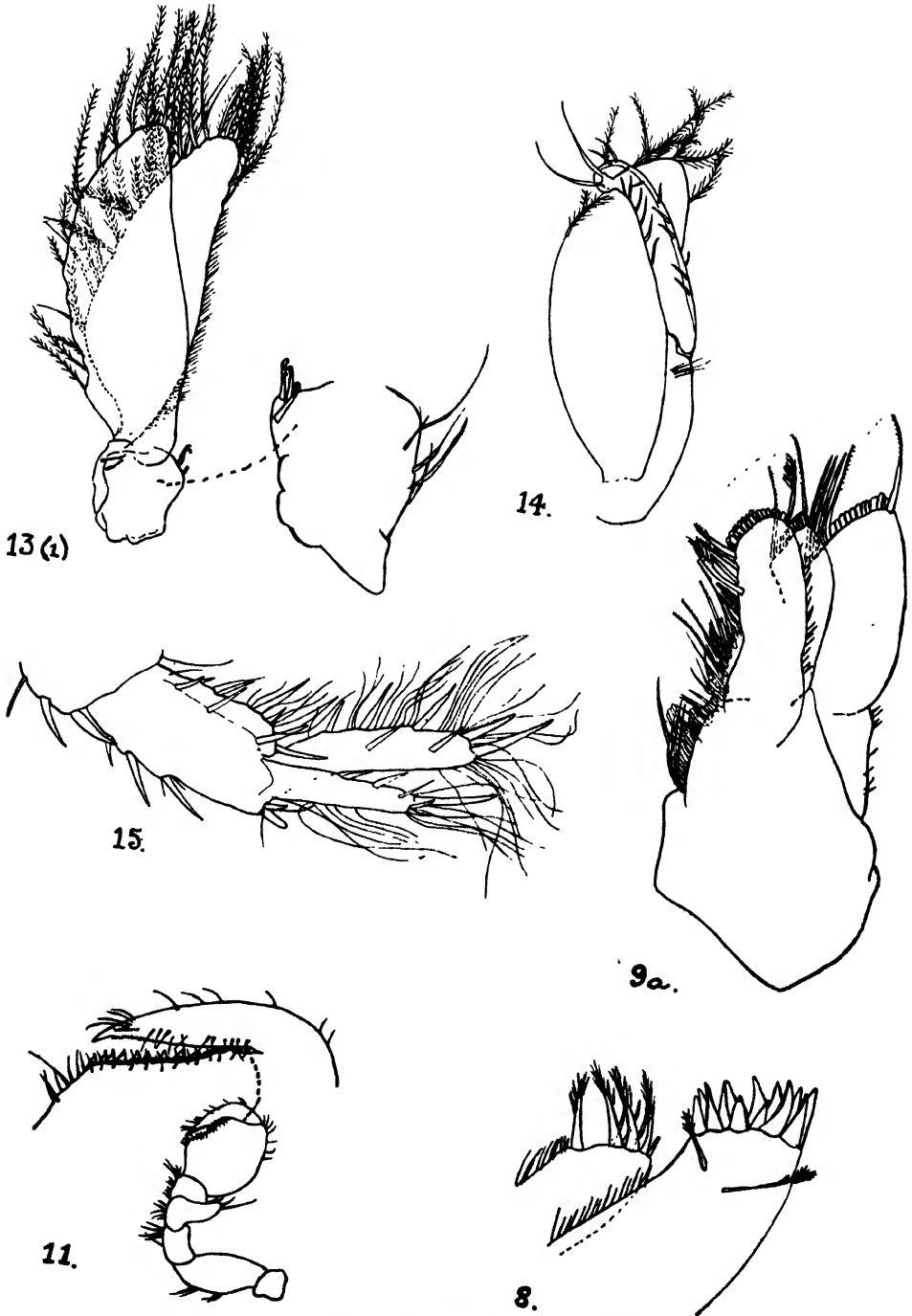
The *maxilla* (fig. 11, 9) differs most noticeably from that of *capensis* in that, in the proximal endite, the basal portion is more evidently defined from the distal, although the junction of these makes a much less obvious angle. The outer of the distal endites, too, is unusually broad.<sup>(1)</sup>

The *gnathopod* (fig. 11, 11) of the male differs in that the ischium is shorter relatively, the greater part of the posterior border of the propod is bare of setae, the palm being well defined and the dactyl setose and minutely denticulate. The remaining peraeopods call for no particular comment.

In the *first pleopod* (male) (fig. 11, 13), the lamellae are equal and similar, bluntly lanceolate, exopodite fringed with about twenty plumose setae, distributed along its whole outer border and the distal fifth of the inner border. Just sub-marginal, and widely spaced, along the lateral edge are a dozen stiff slender setae, while on the inner margin there is a dense fringe continuing from the end of the plumose series to the proximal end of exopodite in a single series of very fine setae. As compared with *capensis*, the endopodite has fewer plumose setae (about a dozen) more widely separated and restricted on the lateral border to the distal half, while mesially these setae extend proximally for a shorter distance. There are no simple setae on this lamella. The sympodite (fig. 11, 13(1)) is sub-quadrangular (widening distally) with a suggestion of a proximal segment, devoid of setae. Distally, on the outer border are four long, simple, marginal setae and one shorter sub-marginal spine, the inner distal angle bears three slender coupling hooks springing directly from the sympodite.

The *second pleopod*. The sympodite is broader distally, its mesial distal angle produced (but without definite lobe) and bears only two coupling hooks and three stiff entangling setae. The outer border is unarmed, but terminally there is one stout sub-marginal spine. The exopodite shows the distal lobe narrow with a length twice its breadth, and bearing about fifteen stout plumose setae. The proximal joint is wide and has twelve to thirteen plumose setae laterally followed by about four or five simple setae towards its proximal end, which is produced into a large, lateral lobe. Mesially, there are a couple, only, of plumose setae distally followed by a multiple fringe of short fine setae passing proximally around a smaller mesial lobe. In the male, the endopodite (fig. 11, 14) is oval in shape, almost as long as the proximal lobe of the exopodite and bears nine plumose setae around its rounded apex. The distal half of its inner border is separated as a penial stylet, an incomplete, scroll-like tube almost straight but curved and

(<sup>1</sup>) Cf. *Hyperoedesipus*.

FIG. 11.—*Mesamphisopus abbreviatus* (Barnard).

produced apically, where it carries two long curved setae.<sup>(1)</sup> Both of the inrolled edges are armed with short, stiff setae. Proximal to this, the basal half of this border is obviously muscular but is not separated from the rest of the endopodite.

The remaining pleopods have each the usual epipodite and show the endopodite decreasing slightly in size and with fewer plumose setae; coupling hooks fewer, generally one only on the third and wanting usually in both fourth and fifth.

The *uropod* (fig. 11, 15) has a short, deep peduncle which is thin and laminar, its inner mesial edge produced and armed with spines, the two distal being, as usual, the strongest. The ventral edge bears three tufts of mixed spines and setae, and beneath the insertion of the rami, there is one stout simple spine flanked by another similar but much smaller spine. The inner ramus is lamellar, as long as or longer than the peduncle, and bears marginal and apical spines and numerous long setae; the much shorter outer ramus has a terminal spine which may be very long, and, laterally, a variable number of spines and setae; the appendage, as a whole, is apparently quite inconstant in its armature of spines and setae.

*Colour.* In spirit, dull grey.

*Size.* Probably not exceeding 10 mm.

*Locality.* 'Northern Slopes of Kogelberg, in the Southern part of the Hottentots Holland Mountains'. Barnard, 1297, p. 157.

### **Hyperoedesipus** Nicholls and Milner

Nicholls and Milner (*Hyperoedesipus*), 1923, p. 23.

Sheppard (*Phreatoicoides*), 1927, pp. 83-84.

Body slender and vermiform, maintaining a nearly uniform width and depth, its length about nine times the greatest width; covered fairly uniformly with long setae, head large and long, its length exceeding both its width and depth; sub-ocular incisure wide and shallow, mandible forwardly displaced, cervical groove feebly developed, posterior process wanting; eyes absent; peraeon wider than deep, with first segment free from the head, very short but greatly expanded ventrally, the second to fifth peraeon segments of fairly uniform size; pleon not greatly shortened, but the pleura almost obsolete; in the female, the fifth segment unusually short; the tailpiece relatively long, not wider than peraeon, its hinder border shallowly emarginate above a small flattened postero-ventral surface. Antennule short, few-jointed, both mandibles with lacinia mobilis; maxilla somewhat reduced and differing on opposite sides; gnathopod, markedly different in the two sexes, being in the male very strong, propod with concave palm, dactyl long; all of the pleopods bear on the sympodite both coupling hooks and entangling setae, exopodite with abundant plumose setae but endopodites without setae and considerably reduced, epipodites wanting. Uropods strongly developed, peduncle produced into strong process mesially at its distal end, terminal spines beneath the rami, short, toothed; outer ramus constricted sub-terminally and produced into narrowed apex.

*Genotype.* *Hyperoedesipus plumosus*, Nicholls and Milner.

Concerning this genus, Sheppard states (1927, p. 83) that 'after careful examination and comparison' of *Hyperoedesipus plumosus* with *Phreatoicoides gracilis*, she was convinced that 'the difference between the two are not sufficient to justify the formation of two distinct genera'. Accordingly, the name *Hyperoedesipus* was relegated to the rank of synonym of *Phreatoicoides*. It would, indeed,

(<sup>1</sup>) As in *Hyperoedesipus*.

not have been unreasonable to have formed this opinion had it been based on no more than the original description (1923), marred as that is with its regrettably numerous errors and omissions, these latter including several of the more significant features. But after 'a careful examination' of an actual specimen, attention should have been called to the more obvious mistakes, and some, at least, of the omissions remedied, and in that case it might well have been expected that a different opinion would have been formed.

The oversight in the original account of two of these characters, which were really quite obvious, and are of considerable importance, is inexcusable; they are:— (1) the presence of a lacinia mobilis on both mandibles, and (2) the occurrence of coupling hooks, associated with long setae, on the sympodites of all the pleopods. It was unfortunate that in a revision of the family, these details, at least, were not observed; on the contrary, in the case of the first, Miss Sheppard repeats our error, stating (l.c. p. 119) 'the right mandible does not bear a lacinia mobilis'.

The occurrence of coupling hooks on all the pleopods, invariably associated with long entangling setae, provides a character found in no other genus. In the writer's view, this is the retention of a primitive condition, from which could have been derived that found in other Phreatoicids; for the Amphisopine forms have coupling hooks on some pleopods without setae and the typical Phreatoicids have lost coupling hooks but have retained and even augmented the group of long setae.

Further, the marked difference in the position of the mandibles and in the proportions of the tailpiece of the two genera were not observed. That these differences between *Hyperoedesipus* and *Phreatoicoides* could be overlooked when the two species are placed side by side is surprising.<sup>(1)</sup> In the former, the tailpiece of the male is no wider than the peraeon and in the female rather narrower, whereas in *Phreatoicoides* the tailpiece is, in both sexes, wider than the rest of the body, making a quite conspicuous swelling when seen from above and constituting a feature peculiar to that genus;<sup>(2)</sup> while the forward displacement of the mandibles in *Hyperoedesipus* has no exact parallel in other Phreatoicids, although most nearly approached in some *Mesamphisopus* species.

Although failing to correct these errors in our description, Miss Sheppard questions the accuracy of our statement that in the peraeon the first segment is half or less than half the length of the second. In the many specimens which were examined, some inconstancy was found, the length varying from one-third (in some females) to almost half (in typical males). It is, however, greatly expanded below to extend forwardly upon the head exactly as in other Amphisopine forms, so that the general appearance of this region is strikingly different from that of *Phreatoicoides*, where the first segment (which, too, is variable in length) may be almost, or quite, as long as the succeeding segment, and scarcely, or not at all, forwardly produced.

The slender sub-cylindrical body, with a coat of very flexible setae, the absence of eyes, the elongate antennae and reduction of maxillula and maxilla, the massive hand on the gnathopod, slender peraeopods with no widening of the bases in the hinder group, the shortening of the penial stylets, and the striking reduction of the endopodites in the pleopods and of the pleura in the pleon, are all features reasonably to be attributed to adaptation to life in subterranean waters. Probably, many of these features have been developed independently several times in Phreatoicids in widely separated localities. An elongation of the head (particularly in the post-mandibular region) and the general elongation of the body, resulting

(<sup>1</sup>) No specimen of *Phreatoicoides* was available to us when the account of *Hyperoedesipus* was published.

(<sup>2</sup>) Perhaps, *Hypsimetopus*, also.

in a more nearly uniform length of the segments in the peraeon, may likewise be features related to the mode of life. There is yet another character which may perhaps be adaptative, to which it appears attention has not been directed—viz., the flattened posterior surface of the telson in these subterranean forms. There is here not the shortened stump of a telsonic spine, found so generally in Phreatoicids, but the variable development of a wide, flat, postero-ventral surface, onto which the anus opens, this condition being (hitherto) recorded elsewhere only in *P. assimilis*. Actually it occurs in *Phreatoicopsis*, *Phreatoicoides*, *Notamphisopus*, and, probably, in *Hypsimitopus*.

On the other hand, in the retention of a relatively longer pleon, of the lacinia mobilis on both mandibles, of more numerous spines (simple and setose) on the inner endite of maxillula, of coupling hooks on the sympodites of all the pleopods, of a fringe practically completely composed of plumose setae on the exopodite, and of the almost laminar condition of the rami of the uropods, there are found characters which not only mark the more primitive Phreatoicids, but which sharply distinguish this genus from *Phreatoicoides*. Although the penial stylets are short in both genera, they are otherwise quite unlike, that of *Hyperoedesipus* differing little from the condition found in *Mesamphisopus*, whereas that of *Phreatoicoides* appears to be reduced from the condition in *Phreatoicopsis* or *Amphisopus*.

If, then, there are excluded the features enumerated as adaptations to life in waterfilled underground crevices, the parallel loss of epipodites is almost the only significant feature recorded that is common to the two genera which Miss Sheppard would unite. Giving due weight to all the facts, it would seem that the separation of *Hyperoedesipus* from *Phreatoicoides* is fully warranted. Further, it seems probable that the two genera are not even closely related, most of their 'likenesses' being attributable simply to parallel and even convergent evolution as a consequence of adaptation to a precisely similar mode of life. *Hyperoedesipus* seems to find its nearest kinship in the South African *Mesamphisopus*, both presumably being descended from a common Gondwanaland ancestor.

### **Hyperoedesipus plumosus Nicholls and Milner**

(Figs 12, 13)

Nicholls and Milner, 1923, pp. 23-33, pl. 2-5 (*H. plumosus*).

Sheppard, 1927, p. 129 (*Phreatoicoides plumosus*).

In many details, the original account is misleading, important features being omitted or insufficiently stressed; it is desirable, therefore, that a more correct description should be available, the more so as the species may be nearing practical extinction.

*Body* (fig. 12, 1*d*, 1*s*) slender, vermiform, tapering not at all, although there may be an insignificant narrowing of the head anteriorly, and, also, of the end of the tailpiece; the length is nine times the width which is practically uniform, and, in the male, is greater than the depth; in the female, the body is broader, so that the length is little more than eight times as great as the width, which is almost equal to the greatest depth of the pleon; the surface smooth with fine setae scattered generally, but an arrangement of these in transverse rows is suggested on some of the pleon segments.

The *head* (fig. 12, 2*s*) is moderately large, sub-quadrangular in dorsal view, its anterior border concave; a sub-ocular incisure is well marked, and from this the front seems to rise more steeply in the female than in the male. Below the



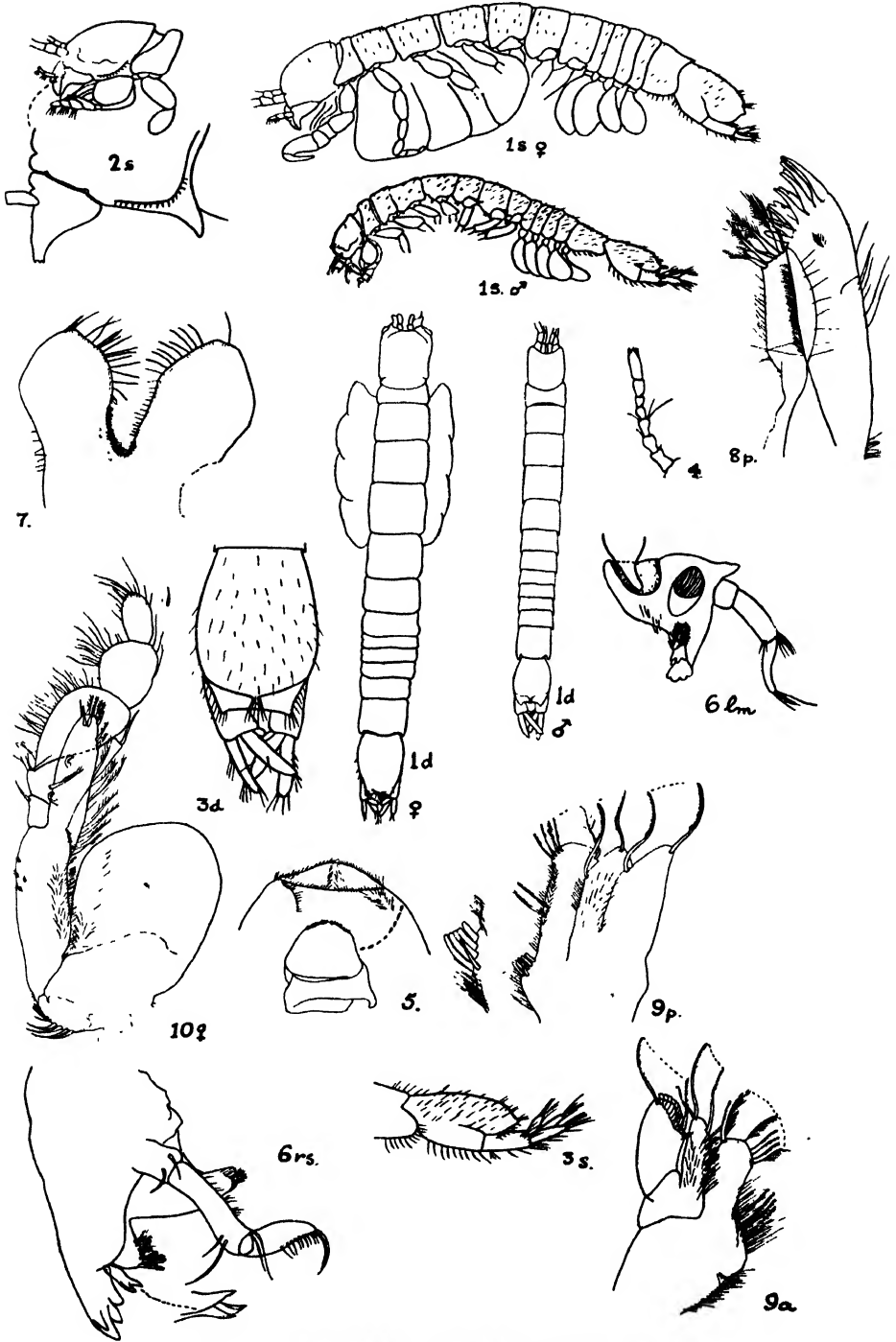


FIG. 12.—*Hyperoedesipus plumosus* Nicholls and Milner.

incisure no sub-ocular segment is discernible and the mandible extends with an oblique articulation to the extreme anterior margin of the head. Eyes, genal groove and cervical groove all are wanting unless a faint upward continuation of a seta-bearing ridge, rising from the ventro-lateral border of the head, is the last vestige of the latter. Behind the mandible, the ventro-lateral border of the head is practically horizontal but is sharply downturned posteriorly. The 'posterior process' underlying the hinder angle of the body of the mandible in many Phreatoicids is here wholly wanting. The hindmost head appendages seem to be attached very far back, below the wide intersegmental space separating head from peraeon, they lie, nevertheless, anterior to the bases of the gnathopods.

In the *peraeon* there is, in the male, a near approach to uniformity in the length of the segments with the exception of the first and last; the first is quite short in the mid-dorsal line but expanded greatly ventro-laterally, so that it may be produced forwardly to overlap the head, from which, however, it is wholly free! In the female, this segment is short, but the ventral expansion is notable. The sixth and seventh segments are sub-equal, but shorter and deeper than the preceding segments in the female; in the male the seventh is more markedly shortened.

In the *pleon*, the first to fourth segments are sub-equal; in the female, the length of the fifth segment is equal to that of the third and fourth combined, and its depth almost uniform, whereas in the male, the fifth is longer and practically equal to the combined length of segments one to three, its depth, however, decreasing considerably posteriorly, so that the body can be seen to be constricted at this point.<sup>(1)</sup> This appearance of constriction is not entirely due to the oblique truncation of the fifth pleura for it may be seen (in the male, at least) in dorsal view. The free border of the fifth pleuron is fringed with long setae.

The *tailpiece* (fig. 12, 3s, 3d) is as long as the three preceding segments combined, is narrow anteriorly, widens mesially and contracts posteriorly. In side view, the terminal part is bent sharply ventrally to end abruptly at the shallowly concave posterior margin, the lateral corner of which appears, in side view, as the hindmost point of the body. Below are slight telsonic pleura with a fringe of setae; the dorsal line of insertion of the uropods is continued anteriorly in a suture armed by two or three setae. In front of the uropod, the sixth segment has a straight pleural edge; it is carried horizontally in life and bears a fringe of ten to twelve long setae.

*Antennule* shorter than the peduncle of the antenna, with a maximum (rarely attained) of eight joints, the penultimate long and swollen, the last a mere knob with terminal setae and olfactory cylinders. *Antenna* exceeds half the length of the body; peduncle with first and second joints short and sub-equal, third, fourth, and fifth becoming progressively longer and more slender, the fifth once and one-half to twice the length of the fourth; flagellum, with about thirty joints, almost three times the length of the peduncle.

*Labrum* (fig. 12, 2s, 5) markedly asymmetrical, very large, relatively short and wide, with a fringe of short setae, extending ventrally on the under surface; laterally, the lip is excavated on its posterior surface where the fulcral process of the mandible abuts against and underlies it.

*Mandibles* (fig. 12, 6). These, though showing considerable reduction, retain the characteristic Amphisopine condition. The right mandible has a cutting edge with four bluntly rounded teeth and a slender lacinia mobilis furnished with two

(<sup>1</sup>) In *Phreatoicoides gracilis*, the pleura of this segment have become practically obsolete posteriorly, so that this constriction is wholly exposed and appears much more marked in that species.

or three small, sharp teeth which are minutely denticulate (fig. 12, *6rs*). The fulcral process is conical and unusually long, its free anterior end concealed, in the undissected specimen, by the labrum. The spine-row appears as a double row of toothed spines (about three pairs) followed by a short series of four ciliated spines. The molar is long and slender, a group of three ciliated spines springing from its distal edge. The palp has a long third joint but the number of setae is considerably reduced, there being about three terminal longer setae and six to nine shorter, situated more proximally. In the mandible, dissected free, the adductor muscle is seen (fig. 12, *6lm*) to occupy a small rounded opening well behind the molar and near to the posterior end of the body of the mandible. In the left mandible, the lacinia mobilis has the normal condition of a fairly strong cutting plate, both this and the principal dentate edge variable with three or four teeth. In both, the molar surface suggests a series of parallel pectinate (biting) setae, the distal ends of which appear, in many cases, free and projecting beyond the molar surface.

The *labium* (fig. 12, 7). In all the preparations this structure appears asymmetrical, perhaps due to a distortion sustained in dissection, for it is particularly flimsy and easily damaged. Buried in the very dense fringing setae on the distal and mesial aspects of its paired lobes there seem to be several setospines. In the figure only a few setae are represented.

*Maxillula* (fig. 12, 8). The proximal endite is small, its apex truncated, bearing four setospines, against the first and third of which is a simple spine. The distal endite is armed apically by twelve stout spines. A single short, stout, plumose seta occurs on the posterior face of this endite, whose outer edge bears a series of spinules and sub-marginally at about its mid-length a cluster of slender, finely pectinate setae.

The right *maxilla* (fig. 12, 9) in this species closely resembles that of *M. depressus*, but appears rather variable and has, generally, undergone rather more reduction, while still further reduction has taken place in the case of the left appendage. The proximal endite is sub-triangular in shape, and in the right appendage, the comb of filtratory setae is well developed, although the cilia on these setae are very fine indeed. This row is backed only by a very short posterior line of four or five setae usually, but not invariably, pectinate; proximal to the filtratory series there may be a short tuft of stouter setae (doubtfully pectinate) and this proximal part is fringed with a series of fine, simple setae. Distally to the filter setae the inner border is bare but the apex of the endite, which may be truncate or bluntly rounded, bears a single row of about fifteen pectinate setae, some of which are very stout; the middle lobe has its hinder face and its inner border setose, its apex with a dozen stout pectinate or denticulate setae; the outer lobe is short and unusually broad, its apical setae forming a dense double series. The faces of this endite are free from setae; but proximal to its base, on the outer border of the appendage is a short series of about five setae which spring apparently from the second segment. The *left maxilla* is unique in this sub-order in that the filtratory setae are absent, the whole mesial edge bearing a continuous fringe of short, hair-like setae, the pectinate series reduced to two (rarely four) setae.

*Maxilliped* (fig. 12, 10♀). Like the maxillula and maxilla, this appendage is very flimsy and proves surprisingly difficult to remove undamaged. The coxa is short and broad and bears a rather narrow elliptical epipodite, which is generally unarmed laterally but occasionally with a proximal fringe of setae and with a broad but scattered fringe of short, fine setae mesially. Near its base are numerous

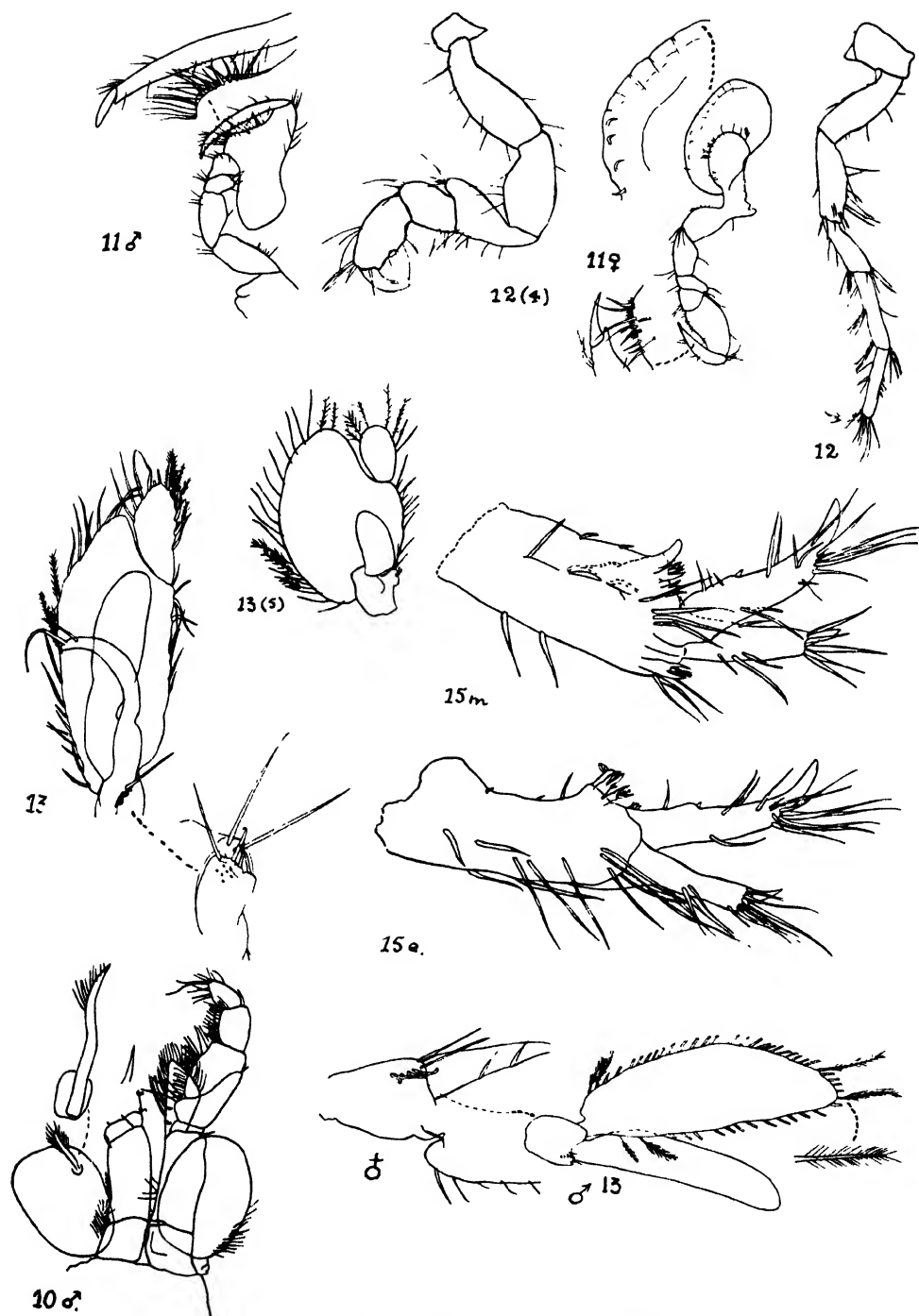


FIG. 13.—*Hyperoedestipus plumosus* Nicholls and Milner.

short lines of very fine setae which here, as in other species, are regarded as the free fringed edge of reduced scales; the basis long, its length more than twice its width; its mesial (posterior) edge set with scale-fringe setae, its antero-mesial edge with a band of short, stiff setae; at its distal mesial angle is the usual stout plumose spine (not shown in the figure); the endite is fringed along its whole length with long and stout setae, of which the more distal eight or nine are typical brush setae; in the hinder mesial edge are two or three stout many-barbed coupling hooks; the apex bears a dense tuft of setae mostly of the biting type. The ischium is, as usual, short, the merus produced distally, the entire inner edge of carpus and of much of the propod with close-set stout simple setae; the sub-oval dactyl has four or five apical setae, its outer border practically unarmed. On the inner aspect of the epipodite of one specimen (fig. 13, 10♂) there is found a stout, partly plumed spine, arising from a shallow pocket. Little significance would attach to such a variation were it not that in one other Peracaridan group (the Apseudidae), a similar plumed process arises normally from the epipodite as part of the respiratory apparatus.

All of the peraeopods have basis and ischium practically of equal length. The anterior four peraeopods are relatively short, basis, ischium, merus, and carpus all appearing short and wide and in all of these, the merus shows some production antero-distally. In the gnathopod of the male (fig. 13, 11) the propod has developed an immense antero-proximal lobe of sub-quadrangular shape, this joint reaching a length more than twice that of the basis, while the slender dactyl is longer than the posterior border of the propod, greatly over-reaching the palm. This is concave distally, convex proximally, with an irregular knife-edge and armed with a few short spiniform setae, a group of more numerous slender, simple setae occupying the rounded hinder angle. The dactyl seems to have a movable claw and a distinct secondary unguis.

The fourth peraeopod is sexually modified in the male to form a sub-chelate hand (fig. 13, 12(4)), the stout dactyl capable of closing down on to the propod, the palmar surface of which is provided with two strong spines; the propod, too, is excavated proximally and can probably close down partially onto the large spine on the carpus.

In the female gnathopod (fig. 13, 11♀) the propod is much smaller, more normal in shape, lacking the anterior prolongation; its palm is not defined and its armature is simpler; the fourth peraeopod differs little from the third.

In the gravid female, the brood-pouch attains to a very large size, and, because of the slenderness of the animal, is clearly visible in dorsal view (fig. 13, 1d.♀). As many as seven juveniles have been found together, these reaching a length of about 2 mm. but normally there are no more than four embryos in the pouch. This has the usual four pairs of lamellae borne on the four anterior peraeopods and not, as stated in our earlier account (1923, p. 31) on third to fifth peraeopods. Such a mistake was possible owing to the curious backward displacement of the pouch and to our unwillingness to sacrifice for dissection the only female specimen then available. There is, however, as in *Mesamphisopus*, a small vestigial lamella on the fifth segment. It is curious, and possibly more than a coincidence, that Barnard (1914, p. 237) and Sayce (1899, p. 136) both fell into a similar error when describing the condition of the female of *capensis*<sup>(1)</sup> and *gracilis* respectively. In all three species, the first lamella is backwardly displaced<sup>(2)</sup> and in the two

(<sup>1</sup>) Subsequently corrected, 1927, p. 147.

(<sup>2</sup>) Related to the fact that the gnathopod is not forwardly situated in this species.

latter, at least, set so nearly vertically that it is not distinguishable without dissection. In *Hyperoedesipus* the anterior lobe of this divided lamella is small and fits closely against the coxa of the maxilliped and the coxal lobe of that appendage is reduced, appearing as a small undivided plate with but few hooked setae, disposed vertically in an oblique antero-lateral plane, the pair closing the median gap between the anterior lobes of the first pair of oostegites. These latter are small, the anterior plate oval with short plumed setae, the hinder portion larger with three or four marginal setules (fig. 13, 11♀).

The three peraeopods of the hinder group are longer, increasing progressively in length, with all the joints slender. In life, the fifth pair are almost invariably carried upturned, above the level of the dorsal surface.

The *pleopods* (fig. 13, 13) are distinctive, for, although the endopodites have undergone greater reduction in size than in any other Phreatoicid, except possibly *P. gracilis*, and in the three hindmost, the epipodites are wanting, yet the coupling hooks remain better developed than in even the most active of surface-living forms and are, moreover, associated with entangling setae. On the first pleopod there are variably from four to seven coupling hooks and three setae, while the fifth has four long setae and but a single coupling hook. Associated with the retention of this full development of the coupling mechanism (a natatory device) may be the fact that, in this species, the plumose setae on the *exopodite*, likewise, reach their maximum development, commonly fringing the *entire mesial border* as well as occupying the whole lateral border to its proximal end. Here, as elsewhere in this species, there is some variation, simple setae replacing plumose setae occasionally and the mesial fringe is sometimes sparse. The unusual occurrence of plumose setae springing even from the extreme *proximal* end of the exopodites might be supposed to be a development made possible with the gain of freedom from the restriction of pleura. It should be noted, however, that in *Phreatoicoides*, where the pleura have become even more reduced, both exopodite and endopodite are practically bare of setae of any kind, and in *Hypsimetopus*, where even the endopodite may retain plumose setae (first pleopod), the proximal part of both lamellae bears comparatively few setae, none of which are plumose. It seems probable, therefore, that in this abundant development of plumose setae, as in the related persistence of a complete coupling mechanism, *Hyperoedesipus* shows further evidence of a primitive condition and of its affinity with *Mesamphisopus*.

In the male, the penial stylet on the second pleopod is unusually short, curved along its whole length, but otherwise approaching most nearly the condition of that of *Mesamphisopus*. It is, however, armed solely with terminal setae, two in number, fringing setae being absent. In one example, the distal lobe of the exopodite attains a quite unusual size, approaching that of its more proximal lobe.

Succeeding pleopods tend to become shorter and the exopodite broader, coupling hooks fewer, and entangling setae more numerous, until in the last only one coupling hook remains with about four long setae. This coupling mechanism springs from the swelling inner border of the sympodite rather than from distinct lobes, except in the fifth, where a well-marked lobe is present. The endopodite of the fifth is much smaller. The armature of setae along the mesial border of the exopodite is noticeably variable and a couple of simple setae (which may be submarginal) may be found even on the distal lobe.

*Uropods* (fig. 13, 15). These appear short in comparison with the long tail-piece; actually, if compared with the length of the body, they are longer than in *Phreatoicoides*. The peduncle is stout and sub-cylindrical, but the median dorsal

edge is produced vertically into an uneven lamina armed with a few spinules, and its mesial distal angle produced into a small process which is rather variable in size. The outer upper border is armed with long slender setae, while on the inner aspect there are a few setae at about the same level. The ventral surface of the peduncle also has a few long setae but no spines, the usual terminal spines beneath the rami represented here by two or three strong setae. On the dorsal surface, however, and passing obliquely to the ventro-lateral corner of the inner side is an incomplete row of rather peculiar trifold spinules which are probably represented in other species by the toothed terminal spines. The outer ramus is shorter than the inner; both are produced to a point terminally, but it is difficult to decide whether or not there is here a terminal movable spine; both bear a sub-apical circlet of setae and in the outer ramus, at least, the ramus is constricted abruptly at the base of the spine, which is flanked by two or three strong spines as in *Mesamphisopus*. The upper border of the inner ramus is produced into a thin irregular vertical lamina and there may be one or two spines as well as scattered setae, in this again recalling the condition of *Mesamphisopus*.

The dorsal telsonic border (fig. 12, 3d) is emarginate and overhangs, as a thin transparent plate, the end of the body which forms a wide, flattened sub-triangular or almost semi-circular surface, and is directed obliquely postero-ventrally. The anal opening is slit-like, visible, as in *Phreatoicopsis*, both from behind and below, and it is this, slightly open, and seen through the upper surface, that gives the appearance of a sub-terminal notch figured in our original account (1923, pl. 5, fig. 11).

*Colour.* In life, whitish, translucent, the intestine showing through as a black thread; in spirit, becoming a dull opaque white.

*Size.* Largest male 10 mm.; female, with brood-pouch, 7 mm.; juvenile, still within the pouch, 2 mm., nearly.

*Locality.* Known only from a spring below Lesmurdie Falls, in the Darling Ranges, about 15 miles south-east of Perth.

Although subterranean Amphipods are found in various localities in Western Australia, this is the only subterranean Phreatoicid so far known there, and its interest is considerable in view of its kinship to *Mesamphisopus*. Discovered nearly eighteen years ago, it has since been sought without success over a wide area. It is apparently to be found only in the outflow of this one tiny spring which is markedly intermittent, never flowing for more than a few consecutive days and in some seasons failing completely. Further, since the proclamation of the Lesmurdie Falls area as a National Reserve, the locality has become much more frequented and increasingly subject to disturbance. Still more serious is the fact that the creek below the Falls is changing its course and has now reached a point within a couple of yards of the spring, the tiny pool into which this once discharged having already disappeared. Apart from that, specimens, never numerous, have become increasingly scarce in recent years. During the winter of 1941, four collecting trips were made, two quite fruitless, one secured five examples only, and another (following a week of gales) yielded more than a dozen. Attempts made repeatedly to keep specimens alive under laboratory conditions have failed completely, all the specimens invariably dying in a few weeks, although many precautions were taken; the species seems to be very intolerant of light; probably, too, it normally lives in water highly charged with oxygen.

When in movement, the pleopods hang vertically, freely exposed, and, if kept under observation in the laboratory in a glass dish spread with a thin film of silt, it is frequently found that the body is so carried that the pleopods sweep

the ground, the creeping movement leaving a trail made by these appendages. In such circumstances, the uropods may, also, drag and kick upon the surface. Usually, however, the pleon is carried well clear of the surface (neither pleopods nor uropods touching), with uropods widely spread like the pincers of a forficulid, the trail then made being slight, principally the work of the gnathopods which are carried well forward, continually clawing at the surface. If there is a sufficient depth of mud, the animal quickly burrows out of sight, employing the gnathopods for this purpose, and it is noteworthy that in practically all Australian burrowers or subterranean forms the gnathopods are exceptionally large. Curiously, the New Zealand subterranean species are not possessed of large gnathopods, so that it seems unlikely that the increased size of these appendages is primarily related to the burrowing habit. In *Hyperoedesipus* the immensely disproportionate size of these, in the male, is probably related to the strain liable to be put, while mating, upon its earth-hold, the breeding season apparently corresponding with the period of most rapid flow in the underground waters. Such observations as have been made indicate that the female is actually gripped only by the fourth peraeopods.

#### Sub-family II. AMPHISOPINAE

Body robust, scaly; head short with cervical groove reduced or wanting; eyes large, prominent, with many ocelli; first peraeon segment short, fused with head which it overlaps in front; telson rounded or emarginate, not produced. Antennule long, filiform; antenna moderately long; coxae of peraeopods fused with their segments, bases of hinder peraeopods broadly expanded, dactyl long; pleopods, with endopodites reduced and without plumose setae; coupling hooks on sympodite of at least first two pleopods, but entangling setae absent on first pleopod; both first and second pleopods modified in the male; penial stylet stout, strongly curved and tapering, without terminal setae; uropods styliform with rami truncated and armed with stout, freely movable, terminal spine. Brood-pouch contains numerous young.

There are included two genera, *Amphisopus* and *Paramphisopus*, both with two species, and both Western Australian. They are unquestionably related, but differ in one or two important features—the condition of the fourth peraeopod in the male, and of the gnathopod. That, of the two, *Paramphisopus* is more primitive in respect to the former seems probable—the particular style of sexual modification of this appendage found in *Amphisopus* is peculiar to that genus and is almost certainly an independent development unrelated, or practically so, to the modification of this appendage in other sub-families. On the other hand, in the like condition of gnathopods of the two sexes *Amphisopus* probably retains the more primitive condition, while the marked difference of this appendage in male and female of *Paramphisopus* may be a consequence of the failure to develop a sexual modification of the fourth.

The shortness of the head and the loss of cervical groove are features common to both genera, apparently related to the forward displacement of first peraeon segment.

The toothed condition in *Amphisopus* of the large spine beneath the insertion of the peduncular rami is a feature Phreatoicine rather than Amphisopine.

#### *Paramphisopus*, gen. n.

*Body* robust, *head* short, sub-ocular incisure slight, posterior process developed, but cervical groove practically obsolete. *Eyes* very large and prominent. *Peraeon*



scarcely compressed (sub-depressed), posterior margin of segments without setal fringe; telson slightly projecting, hinder border convex. *Antennule* scarcely longer than peduncle of antenna. *Gnathopod* markedly different in male and female, fourth peraeopod of male not sexually differentiated, coxa of fifth, sixth, and seventh peraeopods so completely fused with segment that even the suture may be obsolete (in *palustris*), and with basis only moderately expanded; both first and second pleopods modified in the male, coupling hooks not occurring on the three hinder pleopods, but entangling setae are present and these may be pectinate; the terminal spine on the peduncle of uropod, beneath the insertion of rami, is simple.

Genotype. *Paramphisopus palustris* (Glauert).

With two species, *palustris* (Glauert) and var. *fairbridgei*, var. n., and *montanus*, sp. n.

### *Paramphisopus palustris* (Glauert)

(Figs 14, 15)

Glauert, 1924, p. 49 (*Phreatoicus palustris*).

Nicholls, 1924, p. 92, pl. 8, figs 2 & 2a (*Phreatoicus palustris*) and 1926, p. 182 (*Amphisopus palustris*).

Sheppard, 1927, p. 115 (*Phreatomerus palustris*).

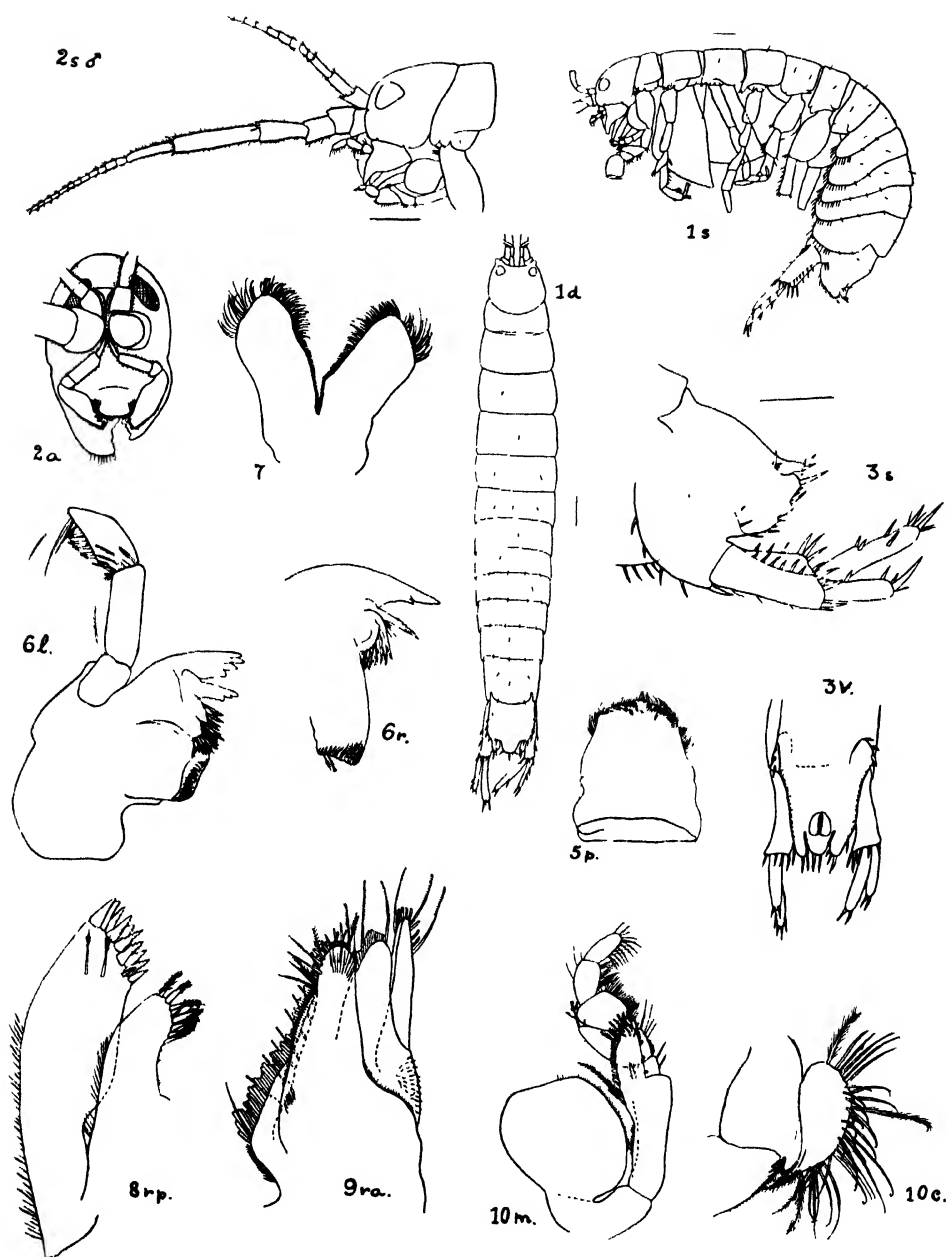
In order to facilitate the comparison of the different species of the Amphipodinae, it has seemed desirable to describe, in considerable detail, one of these lowland forms. For this purpose *P. palustris* (Glauert) has been selected. It is not an extreme type and is, moreover, a form of very common occurrence, which may be taken freely in many of the coastal swamps and lakes in the neighbourhood of Perth, W.A. Further, it attains to a moderately large size, and is thus a convenient subject for detailed study. The original description is quite incomplete.

Body fusiform, surface smooth; *head* (fig. 14, 2) rounded, approaching quarter-spherical in shape, rather shorter than the combined length of first and second peraeon segments, distinctly broader than long, its greatest depth rather less than its width; anterior margin is excavate, the concavity lodging the antennae which are separated in the middle line by a narrow vertical *ridge* (possibly a vanished rostrum); sub-ocular incisure minute; the infero-lateral margin produced forwardly in a 'posterior process'. The posterior border of the head, for much of its extent, is hidden by the obliquely overlapping anterior border of the first peraeon segment. The actual postero-ventral angle is obscured by the coxa of the gnathopod, anterior to which is a ridge. This may be the persistent, lower part of the ridge which borders the cervical groove in *Mesamphisopus capensis*. A short and shallow vertical groove below the eye, extending to the ventral border of the head parallel to the anterior border, partly defines the sub-ocular lobe, behind which is an ill-defined genal groove. Owing to the downward curve of the ventral border of the head, the cheek becomes much deeper where its margin comes into contact with the lateral border of the epipodite of the maxilliped.

The eyes, situated very close to the anterior margin of the head, are many-faceted and prominent, sub-circular or reniform in outline, with about sixty ocelli;<sup>(1)</sup> they are more prominent in the male.

*Antennule* (fig. 14, 2s) shows the first joint of peduncle stout and twice as long as broad, the second barely three-fourths the length of the first and distinctly more slender, while the third is usually more than two-thirds of the combined

(<sup>1</sup>) Bouvier, *vide* Richardson (1905, p. 132), states that in Isopods the number rarely exceeds thirty to forty.

FIG. 14.—*Paramphisopus palustris* (Glauert).

length of the two more proximal joints but is scarcely stouter than the flagellum. This is slender, slightly tapering, little exceeding the peduncle in length, and consists of nine joints in the male and ten (the last a mere knob) in the female; on most joints is a terminal circlet of fine setae and, in the male, a single olfactory cylinder on segments six to eight. Most of the joints are covered with fine setae. In the female, an olfactory cylinder is found on each of the fifth to the ninth articles.

In the *antenna* (fig. 14, 2s) the peduncle is much stouter, the first joint very short, second rather longer, both very broad, the third slightly narrower and longer than the second joint; the fourth almost as long as the combined length of the second and third, while the slender fifth is rather less than the second, third, and fourth together. The flagellum may be twice as long as the peduncle, with twenty-nine joints (some of the more proximal appearing to be undergoing further segmentation), becoming increasingly slender distally, the joints towards the apex being two or three times as long as wide. In addition to the few scattered spiniform setae which occur upon the peduncle, there is a fur-like covering of fine setae, and this is found on some of the flagellar joints, also, while a circlet of fine setae fringes the end of every joint of the flagellum. In the un mutilated state, the second antenna may have a total length three-quarters of that of the body.

The *labrum* is slightly asymmetrical (fig. 14, 5) but roughly semi-circular in shape, deeper than wide, the ventral margin generally setose, the short, curved setae being particularly dense towards the mid-ventral region; the free ends of these setae are directed backwardly (i.e., towards the mouth). On either side of the anterior (fig. 14, 2a) surface is a conspicuous broken line of longer setae, partly visible on lateral borders (fig. 14, 5). These are better developed in some Amphisopine forms, but unrepresented in the Phreatoicinae.

*Left mandible* (fig. 14, 6l). The cutting edge with four teeth, strongly chitinated, dark-brown in colour; the *lacinia mobilis* which, with the conjoined spine row, is capable of a slight mobility,<sup>(1)</sup> is divided into three teeth very similar to those of the outer dentate edge; on the *right mandible* the lacinia is rather more widely removed from the outer edge and is distinctly more slender, less strongly chitinated, paler in colour but retaining the three teeth which are minutely denticulated. The spine-row is strongly developed on the right mandible (fig. 14, 6r), the toothed spines fewer and the anterior and posterior rows less widely separated. On both mandibles, a vertically set comb of shortly pinnate setae fills the gap between spine-row and molar. In the molars, too, of the opposite mandibles, there exist certain differences, that of the right being long and tapering, with obliquely truncated grinding face, sloping from the middle line outwardly and downwardly, and bearing one or two free setae.

The palp, however, is alike in both mandibles, and arises from a small knob-like elevation; the joints are stout, the proximal the shortest, the second twice as long, both cylindrical, the second bearing a terminal circlet of pectinate setae, but a single seta only on the proximal joint. The distal joint, intermediate in length, has a somewhat flattened, pyriform shape with the narrow end strongly curved, the distal two-thirds of its concave border fringed with setae, increasing in length distally and ending in three or four particularly long, curved setae with short pectinations along one edge. In the female, the first and second joints seem more setose.

(<sup>1</sup>) Cannon & Manton (1927, p. 223) note of the *lacinia mobilis* and spine-row in *Hemimysis* that it is 'probably passively movable' with which statement my own observations on Phreatoicoids are in accord.

The *lower lip* (fig. 14, 7) is bi-lobed, the two elongate halves, gaping distally, are not divisible into inner and outer lobes; distally it is convex, well-chitinised, with sub-acute apex inclined a little mesially. The entire inner border is furnished with a continuous brush of curved setae which lengthen towards the apex. In this species (as in some other Amphisopine forms) the fringe includes a rank of setospines, difficult to make out. The convex outer border usually lacks setae terminally, but, with a short gap laterally, the fringe begins anew (here much less dense and composed of curved simple setae) and continues proximally along the remainder of the lobe, the setae attaining their greatest length at about the middle of the fringes. Towards its proximal end, the lateral border is straight or even slightly concave and bare of setae.

*Maxillula* (fig. 14, 8). The inner endite is shorter and, apically, distinctly narrower than the outer. Its distal extremity is gently rounded, and, on both sides, the appendage bears seven stout setospines with two other very slender simple spines. These constitute a close-set fringe which occupies the entire distal border, but are most closely crowded near the mesial edge and actually spread onto the inner (mesial) border. The outer endite is stouter, its obliquely truncated distal end entirely occupied by the broad bases of a double row of strong curved spines, thirteen or fourteen in number, variously denticulated, finely or coarsely, on one or both edges; the usual small postero-mesial setospine is present opposite the second spine, counting from the inner border. Sub-apically, there are two feebly-plumed setae on the posterior face; both endites bear an obliquely-set fringe of fine setae on both inner and outer borders.

Of the *maxilla* (fig. 14, 9) Glauert says (1924, p. 53) that it 'is proportionally shorter and stouter than in the other species of the genus [i.e., *Phreatoicus* s.l.] and the lobes are more curved'. While it is difficult to satisfy oneself concerning the comparative shortness of this appendage, it is necessary to discriminate between actual *length* and the forward extension of the endites in their natural position. Descriptions of the Peracaridan maxilla convey the impression that the proximal endite possesses a mesial *edge*. In the Phreatoicoidea, at least, it actually has a long, triangular and narrow concave mesial *surface*, which may vary greatly in width (antero-posterior measurement), the two edges of which converge to meet distally and are each armed distinctively. The anterior edge is fringed, in this species, with a close rank of short fine setae. Separated from this by the width of the mesial surface is a second ridge carrying a continuous series of long setae plainly showing a division into a short, stouter, basal section, and a distal, more slender finely-pinnate part. This is obviously the rank of filtratory setae of Cannon and Manton's descriptions (1929, p. 177); immediately posteriorly to these there is a row of widely spaced, slender, sparsely ciliated setospines, which spring sub-marginally from the posterior surface. At about one-fifth of the length of the endite from its apex, these last become coarsely pectinate on one side, retaining the setospine condition basally; these extend to and around the apex of the endite where they are very crowded, lying behind a fringe of slender setospines to constitute a double apical row; altogether there may be about twenty-five of them, some twenty of which are more or less ciliated. This proximal endite (the 'fixed inner lobe' of Glauert's description) is stated to be 'much shorter than the two outer articulated members' (1924, p. 53). In its natural position, its relations seem much the same as those of other Amphisopine forms. Its posterior face is clothed towards its apex with a fur of short setae, a condition closely comparable to that figured for *P. terricola*, *S. ambiguus*, and found, also, in *E. kershawi*. Of the two movable lobes which are interpreted the endites of the third segment, the outer is distinctly the wider, although appearing narrower in the figure; both

are, however, quite obliquely set and overlap considerably, the inner member appearing to be partly ensheathed by the outer, and both have practically the same shape, with rounded obliquely-truncate end and convex outer and almost straight inner borders. They are armed terminally with a comb-like series of from fifteen to twenty long curved denticulate spines which lessen in length towards the mesial border. Hereabouts, the base of the comb appears curved out of the plane, this doubtless permitting to each lobe a certain freedom of movement in the transverse plane. The external spine on both of these lobes is generally much stronger than the rest.

The *maxillipeds* (fig. 14, 10m) are large and flattened. The broad but short coxa bears a wide-based epipodite and, in the female only, a large bi-lobed plate which projects stiffly backwards and slightly laterally from its mesial edge and is fringed with long, stiff, finely-ciliated setae, curled towards their ends. The basis, long, slender, and sub-rectangular, is about three times as long as wide, its mesial surface expanded at about the middle of its length into the endite, which is continued almost to the middle of the carpus, where its apex is armed with a dense tuft of assorted setae, passing dorsally, upon the distal half of the endite, into a series of brush setae of continually increasing length, twelve to fourteen in number, interspersed with simple setae. Upon the flattened ventro-mesial surface of this inner plate near its ventral edge are borne two or three strongly curved and minutely denticulate coupling hooks. The very short ischium has a tuft of setae arising from its distal end on both inner and outer angles and is followed by the merus, once and a half the length of the ischium, with its outer distal angle produced along the outer border of the carpus, and bearing three or four widely spaced, pectinate setae. Its inner distal angle is armed with a cluster of setae like those upon the corresponding angle of the ischium but longer and more numerous. The carpus appears irregularly four-sided, its outer side somewhat convexly curved; the mesial border is nearly twice the length of that of the merus and fringed with setae which pass onto the distal border, while the external border has one stout spiniform and pectinate seta which occupies the distal angle; the propod is smaller and sub-oval with an inner setal fringe and three setae on its lateral margin. The dactyl is much smaller but has a similar shape and a closely comparable arrangement of its setae. The epipodite has shared in the elongation of the basis and is a thin curved plate, convex ventrally. Its distal border reaches to the level of the middle of the merus while laterally it touches the post-mandibular border of the head. Upon the distal half of its mesial border, it is set obliquely with a fringe of short and slender setae. Concerning the plate which springs from the coxa (fig. 14, 10c) in the female, it should be noted that, in females with incipient brood lamellae, this coxal lobe, though small, has a fringe of stiff curled setules, while in the anterior lobe of the immature oostegite on the gnathopod there is a scanty edging of setae. It will be recalled that structures similar to the coxal plate, but even better developed, have long been known in other Isopods, and according to Hansen are concerned in the aeration of the brood-pouch (whether by drawing water in, or by bailing it out, is not clear), a view with which Sheppard, who first called attention to these structures in the Phreatoicidae (1927, p. 86) is in entire agreement. While they may so function in other Isopoda, there is difficulty in accepting this explanation for members of this family. In the first place, they are very small (although larger, perhaps, in the Amphisopine forms than in the Phreatoicinae) and project ventrally in an obliquely mesio-lateral vertical plane, so that any current they would create would be almost negligible. Further, there has been found no marked musculature in connection with these lobes. Again, the anterior end of the brood-pouch is

practically closed by the anterior lobe of the gnathopod oostegites and these maxillipedal lobes, which are included, in life, within the pouch, would be likely to be constantly tangling. It is, however, probable that, in the practically quiescent state, the anterior oostegal plates may gape somewhat with any small movement of the leg, in which event these maxillipedal lobes with their interlocking setae could form a most efficient grid or strainer preventing the entrance of coarser particles or of small organisms which accidentally or intentionally might otherwise succeed in reaching the brood-pouch.<sup>(1)</sup> Calman's suggestion (1909, p. 200) quoted by Sheppard, that these lobes are homologous with the oostegal lobes of the following appendages appears entirely probable. That explanation may perhaps be extended by the suggestion that we are dealing here (in this extremely ancient group) with modifications of the gnathobases once present on all the appendages (cf. Entomostraca and Trilobite). In the Syncarida, where there is no brood-pouch, gnathobasic structures still persist on the maxillipeds of the Anasipididae, and comparable lobes even longer, in the female, on the seventh leg of *Paranaspides* and on the fifth and sixth leg of the *Koomungidae*. In the Phreatoicidae we find these lobes on the maxillipeds present only in the female, but they are found as vestiges in the male of *Paramphisopus*, *Amphisopus*, and *Eophreatoicus*. In one species (*terricola*) which in so many ways seems primitive, we find, frequently, in the male, incipient oostegites as well. In the male, too, the genital appendage comes away, in dissection, with the coxa and might easily be a scroll-like modified plate of this series—which origin would account for the frequent appearance of this tube in the female, just as oostegites may be present in the male.<sup>(2)</sup> As regards the aeration of the brood pouch, the structure of the large oostegal plates suggests that these might well function in the supply of oxygen to the larvae (in a fashion analogous to that in which *Protopterus* is said to discharge oxygen to its nestlings through its highly vascularised fin filaments) that is, supposing the oxygen content of the current probably drawn through by the movement of the pleopods was insufficient for the respiration in the embryos.

In the Oniscoidea, there are paired sternal outgrowths (cotyledons) which project from the sternite of the anterior peraeon segments into the brood pouch and may serve as accessory organs for aeration.

The *peraeon and its appendages*. In his description of the peraeon segments of *A. palustris*, Glauert notes 'first segment . . . inferior margin, . . . second, third, and fourth segments . . . lower margin slightly excavate, . . . fifth, sixth, and seventh segments . . . lateral margins convex'. Reference to the *habitus* figure will make it clear that the lateral or pleural margins of all seven peraeon segments must be considered as more or less irregularly excavate, although, in the case of the fifth, sixth, and seventh particularly, the boundaries are indicated only by faint grooves, except at the anterior and posterior ends of the coxa where there exist short incisures. In the more anterior segments, the pleura have become produced downwardly in part into a lobe anterior to the coxa and partly hiding that joint, this lobe being angular, flattened or rounded, and, in every segment but the first, armed with from one to three spiniform setae. In females with incipient brood lamellae the postero-lateral part of second to fourth peraeon segments has a slight flare outwardly, suggestive of the condition which is so fully developed in *P. latipes*. In the male, the coxa has fused immovably with

(<sup>1</sup>) In an earlier paper (1926, p. 200) attention has been called to the fact that in this species, a small stalked Acinetarian which infests the animal makes its way into the brood-pouch and may be found on the newly-emerged larvae.

(<sup>2</sup>) Similar occurrence of these tubes is noted in females of *M. capensis*; but that there may be variably developed a real hermaphrodite condition is an explanation which must not be overlooked.

the overlying body-wall, although the outlines of the joints may still be made out by examination from the inner aspect; of the female, Sheppard has stated that in this species (as well as in *P. latipes*) the second, third, and fourth coxae remain freely movable. If this be a fact, about which the writer has some uncertainty, it is doubtless in relation to the large number of embryos and the consequent size of the brood-pouch and the need for greater freedom of the oostegites.

The *gnathopod* (fig. 15, 11). The coxa is largely hidden by the anterior downward projection of the pleuron to the inner aspect of which it is fused; the basis has a small flattened expansion on its anterior border about twice as long as wide, armed with a spiniform setae and two or three finer setae on the rounded upper anterior angle; the posterior margin has but two or three widely-separated fine setae; ischium almost three-fourths the length of the basis, rounded and almost devoid of setae; merus short, antero-distal angle greatly produced, convex proximally with two spiniform setae, concave distally, one stout spiniform and several finer setae occupying the postero-distal angle. The carpus, which articulates only with the posterior part of the concave distal surface of the merus, forms a rather irregular, short, four-sided pyramid with well-rounded edges and deeply concave base, this cup-like hollow being anteriorly directed and receives the proximal end of the propod, thus permitting considerable freedom of movement to that joint. Along the posterior border of the carpus a few setae are scattered. The propod in the male (fig. 15, 11 ♂) is large and extremely thick, so that the closed hand appears as a sub-globose mass compressed postero-ventrally at the palmar edge. The dactyl slides partly past this edge and comes to rest against the mesial face. A fringe of short setae extends from near the infero-distal angle of the carpus along the ventral border of the propod and the slightly sinuous palm very nearly to the base of the dactyl, but at the rounded (posterior) palmar angle this is reinforced by a rank of stout, minutely-denticulate conoidal spinules of which six or seven are more strongly developed. The convex anterior border of the propod has but a half-dozen or so of widely separated setae; the dactyl is set, along its palmar edge, with short fine setae, has a short fringe dorsally, near its insertion, and several longer setae overhanging the unguis.

In the female, of the same size, the limb as a whole is more slightly built and distinctly shorter; the most notable difference, however (apart from the presence of an oostegite), is seen in the propod (fig. 15, 10 ♀), which is small, relatively feeble, and sub-triangular in outline; its anterior margin is convex, with a few fine setae; the posterior border meets the concave palm in a well-rounded angle, both edges being set with a continuous sparse fringe of setae or spines which are stoutest at the palmar angle. Antero-distally the propod is produced into a slight eminence upon which the dactyl has its insertion. This terminal joint is slightly curved with convex anterior and nearly straight posterior margins, the latter strongly denticulate for much of its length. Just proximal to the unguis is the usual tuft of setae, but a secondary unguis cannot be distinguished in either sex. In a fully-grown female the hand may be larger than that of a mature male.

The second, third, and fourth peraeopods, while all closely alike, exhibit certain differences progressively as they are traced posteriorly. The basis (less stout than in the *gnathopod*) lengthens and develops along its anterior margin a flattened plate which, in the fourth limb, has become quite noticeable.<sup>(1)</sup> The

(<sup>1</sup>) This expansion of the bases of the peraeopods of this anterior group by the development of a plate on the anterior surface of the otherwise rounded joint is probably a primitive condition. It is found in *E. kershawii* and is marked in the fossil *wianamattensis*. It is, however, not always obvious in the entire specimen, due to the fact that these limbs seem capable of considerable rotation and frequently present externally the narrower edge of the joint.

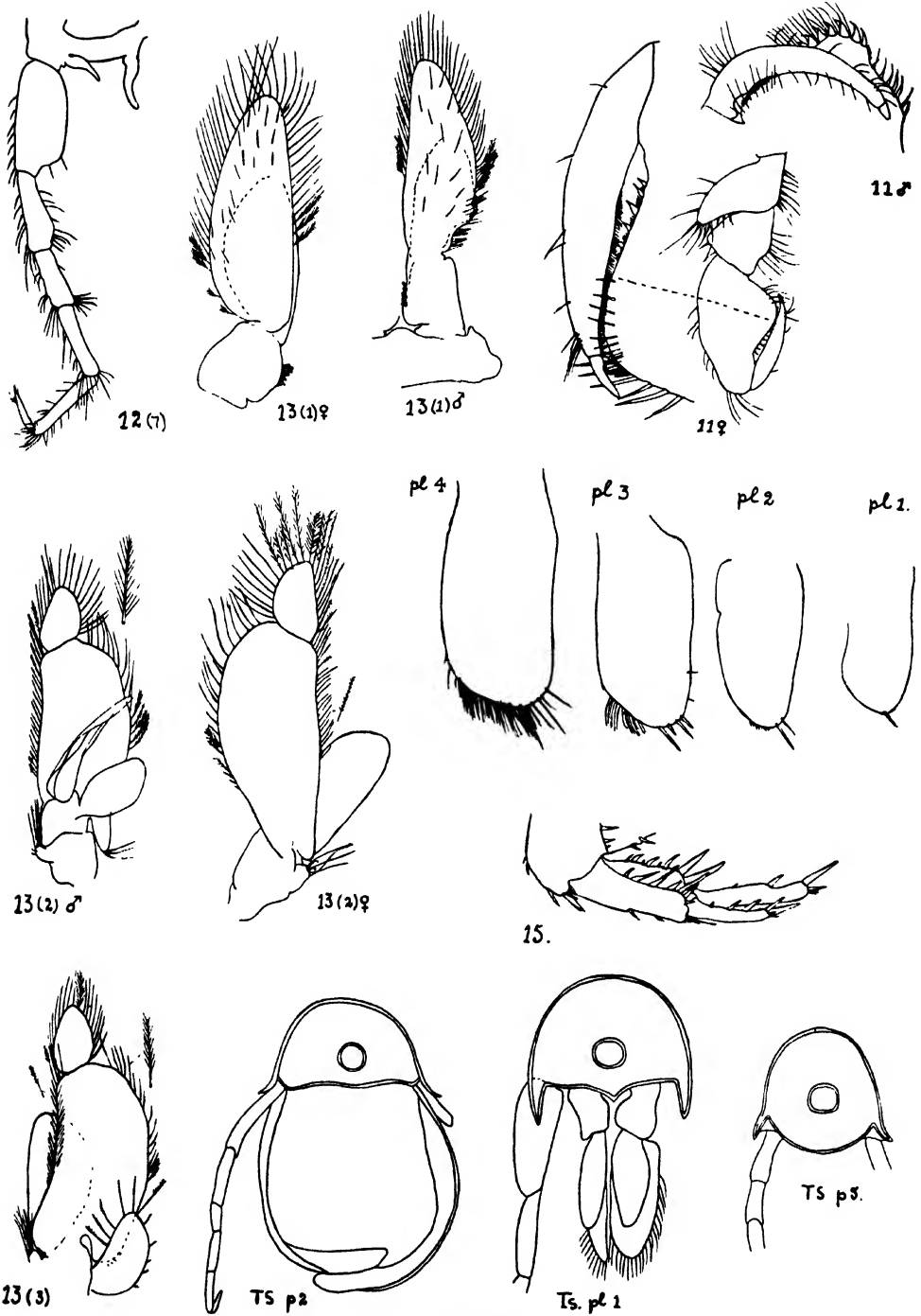


FIG. 15.—*Paramphicropus palustris* (Glauert).



ischium, relatively, is slightly shorter; the merus lengthens and its transverse expansion decreases. In all three of these peraeopods an almost rod-like carpus replaces the sub-pyramidal joint of the gnathopod and, in the fourth peraeopod, has become as long as the merus; the propod is cylindroidal, and the dactyl longer, slender, and almost straight. Its posterior border, set with fine setae, appears serrate and a distinct secondary unguis is present. In all of these peraeopods, the dactyl seems to move within paired flange-like terminal extensions of the propod, and is, probably, capable of being folded down quite extensively in sub-chelate fashion, but there is little suggestion of a palm upon the propod, nor, in the fourth, is there any modification of the appendage into a secondary sexual structure. Glauert states (1924, p. 49) that the female is held *only* by the powerful gnathopods of the male, in which respect the species of this genus differ from the great majority of Phreatoicoidea, so far as is known. These peraeopods of the anterior group are not very strongly setose. Upon the anterior border of all is a small cluster of spiniform setae near the proximal end of the basis, generally including one much stronger seta. Upon the fourth peraeopod, a similar seta (sometimes two), accompanied by five slighter setae, arm the anterior face of the ischium, while the anterior border of the merus has a setal arrangement agreeing with that upon the corresponding joint of the gnathopod; the antero-distal angle of the carpus has a small tuft of mixed, stout and slender, setae, while a group of two setae occupy the middle upper border of the propod and a cluster of fine, sub-terminal setae overhangs the unguis of the dactyl. Upon the inferior border of the basis and ischium are a few scattered fine setae, but upon merus, carpus, and propod there is a series of somewhat stouter spiniform setae fairly regularly spaced on each joint. The setal armature of second and third peraeopods does not differ materially from that of the fourth. In the female, these peraeopods are shorter and less stout than those of the male, but appear to be slightly more setose. The coxal joint of each bears, in the mature animal, a brood-plate which, when fully developed (fig. 15, *T.S. p.2*), reaches a length little less (and in some cases much greater) than that of the related peraeopod. It is markedly pigmented in its proximal (exposed) part, the overlapping portions being without chromatophores. Each widens distally and may be slightly lobed, that borne upon the gnathopod being smallest but very *distinctly bi-lobed*, the two lobes being disposed almost at right angles, the anterior lying transversely to ensheath the base of the maxilliped. In the stage preceding the ovigerous condition, the lamellae are narrow, calcified, and strap-like and lie adpressed to the sternite, overlapping slightly in the middle line.

The three next succeeding peraeopods, in both sexes, form a posterior series. They are backwardly directed and, due to an elongation in every joint, are seen to increase progressively in length as they are traced backwards. In *P. palustris*, they are characterized by an expansion of the basis less notable than in *Amphisopus* spp. This joint consists of the usual flattened cylindroidal piece, but, on its external face, it is produced backwardly into a broad thin flange which, beginning at the proximal end, widens rapidly to reach its maximum in the case of the fifth peraeopod at about the first-fourth of the length of the segment. Here the joint is about two-thirds as broad as long and maintains this width nearly to the distal end of the segment, where it diminishes very abruptly at the 'inferior notch' of Glauert's description (1924, p. 55). Owing to the slightly oblique articulation of these limbs, the more anterior can slide freely upon (external to) the more posterior (Nicholls, 1924, pl. 1, fig. 2), and all can be upturned considerably, the arrangement of the broadened part of the plate being such as to

permit of unhampered movement of the proximal joints.<sup>(1)</sup> In the natural position for walking or swimming, these three plates constitute a very considerable anterior expansion of the natatory and respiratory channel provided by the pleura of the pleon region, producing it forward, in the female, to the posterior end of the brood-pouch. The observed activity of Amphispine species, as contrasted with Geoffrey Smith's observations (1909, p. 71) made upon some Tasmanian Phreatoicids, may well be related to this structural difference, for in the greater number of Tasmanian species these bases are either but little or not at all expanded, the pleopods may be presumed less efficient as swimming organs (the animal would appear to move almost wholly by crawling), losing the natatory function, while retaining the respiratory. The remaining, more distal, joints of these peraeopods are rounded and tend to enlarge slightly towards their distal ends; carpus and propod are sub-equal, more slender and much longer than the corresponding joints of the limbs of the anterior series; the dactyl, also, is elongated.

The anterior border of the bases is set with spinelets, its posterior border provided with fine setules only. On the other joints, setae are presented almost wholly by the larger spiniform type. In the dactyl, the secondary unguis is little more than a slender spinule; the outer terminal cluster is reduced to a couple or even a single seta. This setation is modified in the seventh peraeopod (fig. 15, 12(7)), and the basis differs notably from that of *Amphisopus* in the setal armature.

In the *pleon*, the notable feature is the considerable development of the pleura. The first four segments are, as already noted, sub-equal and rather shorter than the peraeon segments. They are, however, quite unlike in the degree to which the pleura are downwardly produced, deepening progressively from before backwards. The hinder margins of pleuron and segment meet in a gently-rounded curve, the pleura being longer (antero-posterior measurement) than their related segments. Of necessity, therefore, they overlap externally (from before backwards) to a varying extent dependent on the straightness or the curvature of the body, the maximum overlap occurring, of course, when the animal is completely curled up. The first is shallowest, extending distally to *two-thirds* of the depth of the basis of the seventh peraeopod. It widens for nearly half its length, then narrows to a rounded apex, armed sub-terminally on its hinder border with a single slightly curved short *spiniform* seta. The second, third, and fourth pleura increase progressively in length, have a gently convex inferior margin provided with stiff setae or setules on the antero-distal angle, increasing in number from two to ten. On third and fourth there is a series of long setae postero-distally. The fourth and fifth have a fringe of about ten spiniform setae, spaced along the inferior margin, mingled with numerous delicate hair-like setae; the posterior border of the fifth has quite a large re-entrant angle where segment and pleuron meet. In all, the posterior margin is entirely free from setae, differing conspicuously in this from *Amphisopus* spp. Deep as are the pleura, they fail, nevertheless, to conceal entirely the pleopoda, and in life the lower ends of these may be seen waving well below the ventral edges of the pleura.

The *pleopods*. These differ relatively little in length (dorsi-ventral measurement), the first pair being perhaps very slightly shorter than the second or third, and sub-equal to fourth or fifth. The length of the first pair is, however, made up materially by the well-developed sympodite which is, both relatively and actually,

(<sup>1</sup>) In the Amphipoda, the mobility here in a dorsi-ventral plane is probably increased still further by the freedom of the plate-like coxae (epimera). In Phreatoicids, the pleopoda have perhaps a lessened importance as swimming organs, but the existence of the peraeonal extension forwards of the pleon pleural wall should make the current created by the pleopods more effective in the flushing of the brood-pouch.

longer than in succeeding limbs. In width, there is a distinct and progressive increase from the first pair backwards.<sup>(1)</sup> In every case but the first, the pleopod shows the sympodite as a somewhat flattened conoidal mass, bearing distally two unequal lamellae, of which the exopodite is variably pigmented, and the endopodite has only about two-thirds the length of related exopodite. The exopodites are notably setose, the setae being for the most part plumose, the fringe generally more or less wanting latero-proximally in the most posterior of these appendages. Here, the lamellae reach their maximum width and practically extend, completely from side to side of the respiratory archway. The endopodites, invariably without setae, are narrower than the related exopodite, but tend to show some increase in size progressively from the second to the fifth.

*First pleopod.* The sympodite is roughly quadrangular, longer than wide, and narrowing distally, although this is masked by the development anteriorly of a convex mesial flange-like portion set with a complex coupling-hook apparatus. These hooks are numerous and arranged in an unequal double row on the two appendages; that, on the right, may be accompanied by one long flexible seta. The hooked part of the structure has a shape recalling the fluke of an anchor. The endopodite is a rounded oval lobe (not distally emarginate as in *M. capensis* or *A. lintoni*) springing from the distal mesial border of the sympodite, about two-thirds of the length of the exopodite. The latter consists of a narrow, undivided lamella, sub-acute and bordered almost continuously with setae, except for a quite short stretch proximally. Upon the mesial border the setae are finely feathered, and a number of simple setae (some almost spiniform) spring sub-marginally from the anterior face of the lamella. In the male (fig. 15, 13(1)♂) the proximo-lateral portion of this lobe is strongly excavated.

*Second pleopod.* The sympodite is shorter relatively and narrows more sharply towards its distal end. From the distal end of its mesial edge arises a well-marked lobe, its rounded apex set with a group of long, stiff setae which interlock with those of the opposite cluster. Intermingled with these setae are a few (two or three) coupling hooks. The exopodite is longer and broader than in the first pleopod and is obliquely divided distally to form in a small articulated second lobe. On its lateral border the exopodite is produced proximally into a lobe reaching dorsally almost to the sternite. The few setae borne by this lobe are simple, while those on the mesial border of the exopodite are pectinate, the lateral and terminal setae being plumose. Sub-marginal setae are few and very fine. In the female, the endopodite resembles that of the other appendages, being an oval lamella extending distally for about two-thirds of the length of the basal exopoditic lobe. In the male, the endopodite is divided transversely into a proximal joint, thickened and muscular, and a distal portion subdivided lengthwise into inner penial stylet and outer respiratory lamella,<sup>(2)</sup> which is smaller than the endopodite of the corresponding limb in the female. The stylet is a stout, curved rod, tapering markedly to its extremity, devoid of setae, and exceeds the level of the distal end of the related lamella. It is irregularly scroll-like, forming an incomplete tube, the edges of the groove set with a close fringe of oblique setae.

*Third, fourth, and fifth pleopods.* These differ from the foregoing not only in their proportions, but also in the retention of an epipodite. This springs from

(<sup>1</sup>) The powerful muscle related to the pleopod seems to be attached to the inner aspect of the pleural expansion at the point of junction of this with the tergum.

(<sup>2</sup>) Said by Calman (1909, p. 206) to represent a distal endopoditic joint in some Isopods. In *Phreatoicopsis* and *M. capensis* a small swelling upon inner border of endopodite occurs on third pleopod at the level of the penial stylet of second pleopod in the male.

the proximal outer border of the sympodite. In shape, it is a bent oval or sub-reniform, articulating with the sympodite by but a narrow base. It is fringed with long setae which appear simple, but are actually finely feathered apically. On the mesial border of the sympodite there is a small setose lobe, differing in no essential from that described as present on the second pleopod, excepting for the absence of coupling hooks.

As Chilton has pointed out, the division of the exopodite of the pleopoda (except the first) into two distinct joints is not common in the Isopoda. In some specimens, the bases of the long plumose setae *appear to be continued proximally toward the axis of the joint*. While this may be only an artifact due to some protoplasmic retraction it may, nevertheless, well be that these lamellar structures (known only in Isopoda and much more nearly linear in Tanaidacea) have arisen from multi-jointed biramous appendages of the Syncaridan type (still found in the Mysidacea and Amphipoda among the Peracarida), by the flattening of the axial joints and the confluence of the adjacent bases of plumose setae and further confluence of the joints of which only a terminal group has retained independence (and that only in the Phreatoicidae), even this being lost in the first pleopod which has already attained the condition of most Isopoda. The modification has gone further in the endopodite, in which only in the second pleopod is there any indication of a second joint, and all the unfused setal fringe is lost, except in *Mesamphisopus*, where both lamellae are setose and plumose, and in *Hypsimitopus* and in a few New Zealand species, where this condition is still preserved in the first pleopod. This suggestion of the more nearly primitive condition of the Phreatoid pleopods (amongst the Isopoda) is further supported by partial retention of a segmented condition of the sympodite (perhaps the retention of traces of pre-coxae) and the persistence, also, of what are possibly gnathobasic lobes upon these abdominal appendages. If this interpretation be correct, then it is of further interest to note that, although the distal lobe of the exopodite has lost its independence in the first pleopod, that limb, nevertheless, retains in *Amphisopus*, *Eophreatoicus*, and *Phreatoicopsis*, and some New Zealand species, the long sub-triangular shape consequent upon the complete fusion of the proximal and distal lobes, whereas in other Phreatoicids modification has continued till in some genera (e.g., *P. typicus*) this ramus has taken on almost the shape found in the Asellota. It is, of course, possible that evolution has not followed the same lines in these two types and that in *P. typicus*, the Asellota, and others the rounded outline in the first pleopod is the consequence of the actual loss of a distal lobe,<sup>(1)</sup> instead of merely its fusion with the proximal exopodite lobe.

The *tailpiece*. This has a profile which suggests a sub-conical or helmet-shaped body; actually, it consists of the median dorsal or axial sub-cylindrical part downwardly produced on either side into pleural extensions, so that seen from behind (or in transverse section) it is somewhat horseshoe-shaped. The attachment of the uropods appears to be ventro-mesial to the distal edge of this pleuron, and from the dorso-posterior angle of this insertion a spinous ridge, usually armed with three or four spiniform setae, runs upwards upon the tailpiece, which ridge has been interpreted (Stebbing, 1893, Sheppard, 1927, Nicholls, 1926) as marking the sutural line between sixth pleon segment and telson. In this view, all that part of the tailpiece that lies postero-dorsally would seem to be telson. If that be the case, we have, in this family, a broad telson whose pleura are bent downwardly on either side into an arched shape such as is not apparently met with

(<sup>1</sup>) Not infrequently, in life, a terminal lobe has been lost from the hinder pleopods and the mutilated piece is then often strikingly like the shape of these appendages in *typicus*.

in any other Malacostraca. Seen from the side (fig. 14, 3s) the tailpiece presents, dorsally, a gently convex surface, dipping rather more steeply near the posterior end, the actual termination being slightly tip-tilted. This terminal piece projects very slightly, is convex above from side to side, while its posterior margin is also strongly convex. From the dorsal edge of the projection spring three or four stout spiniform setae, cilia-tipped and intermixed with a few finer setae. Laterally, on either side from this projection, the pleura flare outwardly and downwardly. This outward curvature, which is most pronounced dorsally, is little evident, so that a very strong spine crowning a conical prominence (which marks the dorso-lateral angle) appears to spring almost from beneath the terminal projection. The spine is usually accompanied by a spiniform seta and one or two finer setae, while anterior to it, and at the same level, is a smaller sub-marginal spine, difficult to make out against its background. From the dorso-lateral spined eminence, the pleural margin turns much more definitely downwards, though still curving slightly laterally. The edge appears slightly serrated, the serrations lodging in turn a spiniform seta, a large spine, and two progressively smaller spines—all of which are unciliate. It is from the postero-inferior angle that there extends obliquely a ventral ridge marking the internal line of attachment of the peduncle of the uropod. From its lowermost point, the inferior margin of the tailpiece is nearly horizontal, then sweeps forwardly sharply dorsally as the anterior margin of the piece. The postero-inferior angle is occupied by a very stout, *simple* spine and is preceded by three or four curved spiniform setae and a spinule, all approximately equidistant. The upper half of the anterior margin which, in some species, may be sparsely fringed with fine setae, is bare in *palustris*.

The *uropod* (fig. 15, 15) consists of a stout wedge-shaped peduncle, which in lateral view appears sub-triangular, being deepest distally. Its dorsal surface is concave and its inner margin considerably higher than the outer. Upon this inner border are one or two stout spiniform setae, interspersed with spinules; distally the truncated edge bears three stout spines, increasing progressively in size. The outer margin is armed in a somewhat similar way, but the spines and setae not so numerous nor so strongly developed; its narrow ventral border appears unarmed, but actually bears clusters of setules varying from two to five in number, sometimes very fine and usually quite inconspicuous. The two rami are slender and sub-cylindrical, the inner as long as, or longer, than the peduncle, the outer distinctly shorter; beneath their insertion is a stout, curved, simple spine, and it may be accompanied by a setule or spinule. Dorsally, the inner ramus is slightly flattened (cf. *Mesamphisopus*), its borders armed at fairly regular intervals with three paired spines, its end truncated, bearing a long curved, and rather slender spine supported by a second spine and supplemented by one or more spinules or setae. The outer ramus is more slender, has upon its outer border two unpaired spines and its truncated apex is similarly armed with two long, curved and slender spines of quite unequal length. As in the inner ramus, the apical spines may be associated with one or more slender spinules. Usually, these limbs are more spinose in the female than in the male (cf. Chilton, 1894, pp. 260 and 262).

*Colour.* 'Dark olive brown, darkest on the dorsal region, which is separated on the peraeon and pleon from the somewhat paler margin by a light crescentic marking on each of the segments, head marbled, flattened bases, and ischium of peraeopoda five, six, and seven with pale blotches, mottling on the other joints of the legs'. (Glauert, 1924, p. 51.)

*Size.* Male 17 mm.; female 15 mm. (ovigerous specimens may have about 50 eggs or embryos in the brood-pouch).

*Occurrence.* Type locality 'Dog Swamp', Smith's Lake, North Perth; in numerous coastal swamps and shallow lakes in the immediate vicinity of Perth, e.g., at Wanneroo, Claremont, Bassendean, Guildford, Welshpool, etc. Nearly all these swamps are liable to dry out in summer, so that some specimens must presumably survive the summer buried in mud, as Barnard has shown to be the case in some *Mesamphisopus* species, and as is almost certainly the case in *P. montanus*, n. sp.

There is a fair range of variability in specimens from these different localities and it seems probable that at least those from Guildford will require to be separated as a new variety. That from Pinjarra, some fifty odd miles to the south of Perth, is perhaps still more distinct and is described below as a variety 'fairbridgei'.

***Paramphisopus palustris* var. *fairbridgei*, var. n.**

(Fig. 16)

This small form differs from the typical condition in the following characters:—

The *body*, as seen in dorsal view, appears almost parallel-sided in the male, but tapers markedly in the female, the fourth peraeon segment having the greatest width. Actually the animal is markedly sub-depressed.

The *head* (fig. 16, 2s) shows the sub-ocular incisure rather better developed, and, behind, is overlapped by the first peraeon segment to a lesser extent. The *antennule* is relatively a little shorter, and there are minor differences in the proportions of the peduncular joints of *antenna*, the fourth joint being distinctly shorter; there are but twenty joints in the flagellum; the whole appendage is less setose. The eye is relatively large, but with fewer (thirty to forty) ocelli.

The coxa of the *gnathopod* seems less forwardly displaced and the hand (fig. 16, 11) differs in the shape and armature of the palm. In the hinder *peracopods* there are small differences; in the seventh (fig. 16, 12(?) ), for example, in setation as well as in the shape of the ischium and the relative proportions of ischium, merus, and carpus.

In the *pleopods* the latero-proximal excavation on the exopodite of the male is less pronounced, while the *uropod* (fig. 16, 15) shows differences in the armature of both peduncle and inner ramus, as well as in the relative length of the rami and terminal spines.

The anal opening is disposed nearly vertically instead of horizontally as in *palustris*.

In the size of the brood this variety is nearly intermediate between the typical form and *montanus*, there being apparently a maximum of about 32, which is large for so small a species. This may account for the exceptional size of the brood lamella and the markedly depressed condition of the anterior peraeon in the female.

In *colour* this form is practically indistinguishable from *palustris*, but the size of the largest does not exceed 12 mm. It was first taken by the writer in the winter of 1924, in swampy ground and nearby drains on the Fairbridge Farm, W.A. Later (1928) it was collected at Pinjarra some three miles to the south, in ditches emptying into the Murray River, but this area has since been extensively drained and the Phreatoicid is now rarely found.

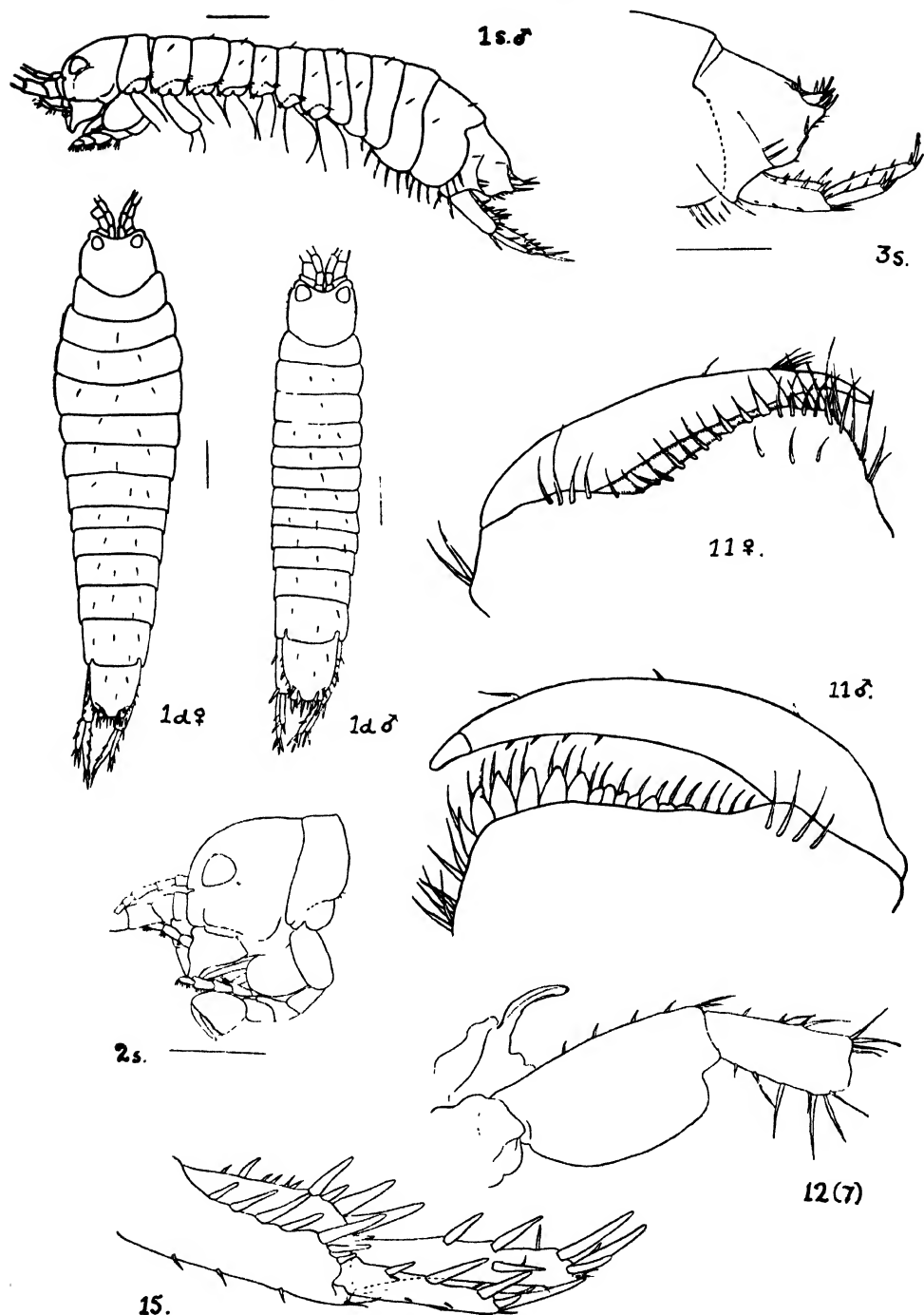


FIG. 16.—*Paramphisopus palustris* var. *fairbridgei*, var. n.

*Paramphisopus montanus*, sp. n.

(Fig. 17)

A small species, superficially very like *palustris*; body smooth, with sparse setae which are short and fine. Head as long as (or perhaps longer than) combined length of first and second peraeon segments; eyes with from fifty to sixty ocelli; first peraeon segment about two-thirds length of the second in female, in the male sub-equal; second, third, and fourth sub-equal and longer than the fifth, sixth, and seventh; pleon moderately deep and longer than the peraeon, the ratio of length of pleon to that of cephalo-peraeon being as 85 : 100; the first three segments are sub-equal in the female; the male shows the first pleon segment shortest, and second, third, and fourth sub-equal; the fifth segment in the male scarcely shorter than the tailpiece, which is as long as the combined length of the first and second peraeon segments, but narrows somewhat sharply posteriorly; telson gently convex, but more deeply notched on either side of the median projection than is *palustris*, its pleural portion not strongly developed and with but few spines.

*Antennule* barely as long as the peduncle of the antenna, first joint little longer than broad, second joint longer than first, flagellum with joints somewhat elongate (eight in the male; seven in the female); olfactory cylinders on at least terminal four articles.

*Antenna* slender, about two-thirds of length of body, flagellum with about twenty-three joints. Upper lip lacks the lateral brush of setae and the palp of mandible is less setose than in *palustris*; epipodite of maxilliped has the mesial border fringed abundantly with long setae. Gnathopod in the male less massive than that of *palustris*, anterior border less convex, posterior border more rounded; in the female, the propod is triangular and the palm straight. In a specimen nearly 8 mm. long, the brood-pouch contained but six or seven embryos (in the coastal species, the number usually exceeds fifty).

The peraeon appendages slightly or not at all pigmented, the bases of second, third, and fourth peraeopods distinctly expanded; of fifth, sixth, and seventh, relatively less developed than in *palustris*, and less setose. The pleuron of first pleon segment narrow and rounded; all pleura in pleon fringed with long setae. Pleopoda unpigmented; sympodite of first pleopod has well-developed coupling plate bearing hooklets, the endopodite is short, little longer than the sympodite and is narrow and sub-acute. The exopodite of the second pleopod bears thirteen plumose setae on the lateral border of proximal lobe; endopodite and penial stylet are of equal length and reach almost, or quite, to the base of distal exopoditic lobe, coupling lobe bears but two to three spiniform setae and two coupling hooks. The succeeding pleopods differ little from those of *palustris*, except that there are small oval epipodites and that coupling lobes bear but two or three spiniform setae and are without coupling hooks.

The *uropods* (fig. 17, 15) are of but moderate length, peduncle not reaching to the end of the telson and armed with numerous long and very slender spines, the terminal pair of the inner ramus being two-thirds the length of the outer ramus.

*Colour*. Pale, scattered black chromatophores on a light background. In spirit, the yellowed muscles may be seen through the exo-skeleton and the specimens appear a pale yellowish-grey. In life, translucent.

*Length*. Male nearly 10 mm.; female with brood lamellae (but not ovigerous) nearly 9 mm.

*Locality*. 'The Lakes', just off the York Road, about thirty-two miles due east of Perth, W.A. This sheet of reed-covered water, which lies upon the summit of the



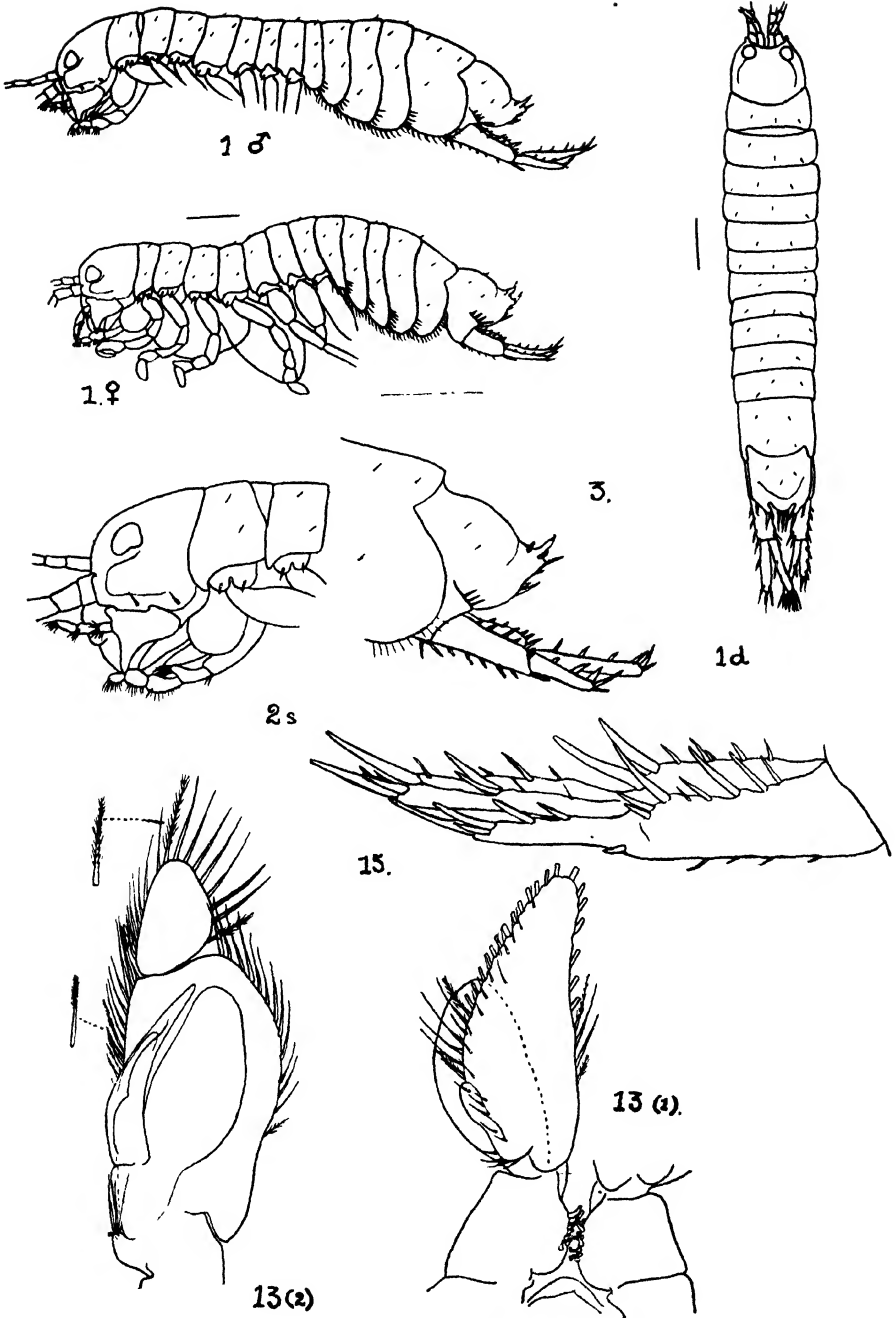


FIG. 17.—*Paramphisopus montanus*, sp. n.

Darling Range at an altitude of less than 1000 feet, practically dries out every summer. The species was first taken in 1926; since then, secured on several occasions. On the latest of these (1/6/1939) a large number was collected.

Co-types are lodged in the collection of the Museum, Perth, W.A.

The description given above is little more than an enumeration of the details in which this species differs from *P. palustris*, which, superficially, it seemed to resemble so closely that it was originally regarded as being a variety (1926, p. 183). In the smallness of the number of the brood there is, however, a character found in no other Western Australian Phreatoicid, except the still smaller and wholly subterranean *Hyperoedesipus*; the greater elongation of the pleon, the relatively greater size of the first peraeon segment, the reduction in the number of ocelli and in the length and number of joints in the antennae, as well as the diminished pigmentation, are characters probably all acquired in adaptation to life more nearly cryptozoic than that led by any other of the known Amphisopine surface-living species. This habit may perhaps be a consequence of the annual recurrence, in the case of *P. montanus*, of a nearly complete drying out of its swampy lake. The lake was dry, when first visited, the specimens actually being taken in thin mud at the bottom of depressions made by the hooves of cattle, where only a film of water still lingered.

### Amphisopus Nicholls

Nicholls, G. E., 1926, p. 182 (*Amphisopus*)

*Head* with short sub-ocular incisure, without cervical groove; eyes large and prominent. *Peraeon* but slightly compressed; *posterior margin* of some peraeon and of all pleon segments fringed with setae; tailpiece with a short median and longer lateral ridges; telson not projecting, emarginate; *antennule* distinctly longer than peduncle of antenna, with numerous short joints; olfactory cylinders on last four to six joints; *gnathopod* of male and female alike in shape, but fourth peraeopod of male sexually differentiated as a modified sub-chelate structure, the carpus being involved as well as the more distal joints; coxae of all peraeopods immovable in both sexes, but the suture defining coxa of the fifth, sixth, and seventh peraeopods persistent, bases strongly expanded; both first and second pleopods modified in male; sympodite of first and second pleopods with numerous coupling hooks and without entangling setae; one stout and two more slender toothed spines beneath insertion of rami of uropod, base of inner ramus twisted as in *Mesamphisopus*.

This definition differs in several details from that originally proposed. This is due, in part, to the exclusion of two species and the addition of one new Western Australian form, as well as to the discovery of a number of characters previously overlooked.

Genotype. *Amphisopus lintoni* (Nicholls).

### Amphisopus lintoni (Nicholls)

(Figs 18, 19)

Nicholls, 1926, p. 182; 1924, p. 93, pls. 8, 9 (*Phreatoicus lintoni*).

Sheppard, 1927, p. 116 (*Phreatomerus lintoni*).

Sheard, 1936, p. 473.

*Body* (fig. 18, 1) moderately stout, surface smooth with few scattered setae; *head* short, scarcely longer than second peraeon segment; eye large, sub-reniform,

with numerous facets (150 or more); *peraeon* sub-cylindrical, segments deeper than long, second, third, and fourth nearly sub-equal, fifth, sixth, and seventh successively shorter, seventh nearly as short as the first; pleura of segments one to four scarcely downwardly produced, only partially concealing the coxae; *pleon* moderately long, having with the telson a length almost three-fourths that of combined

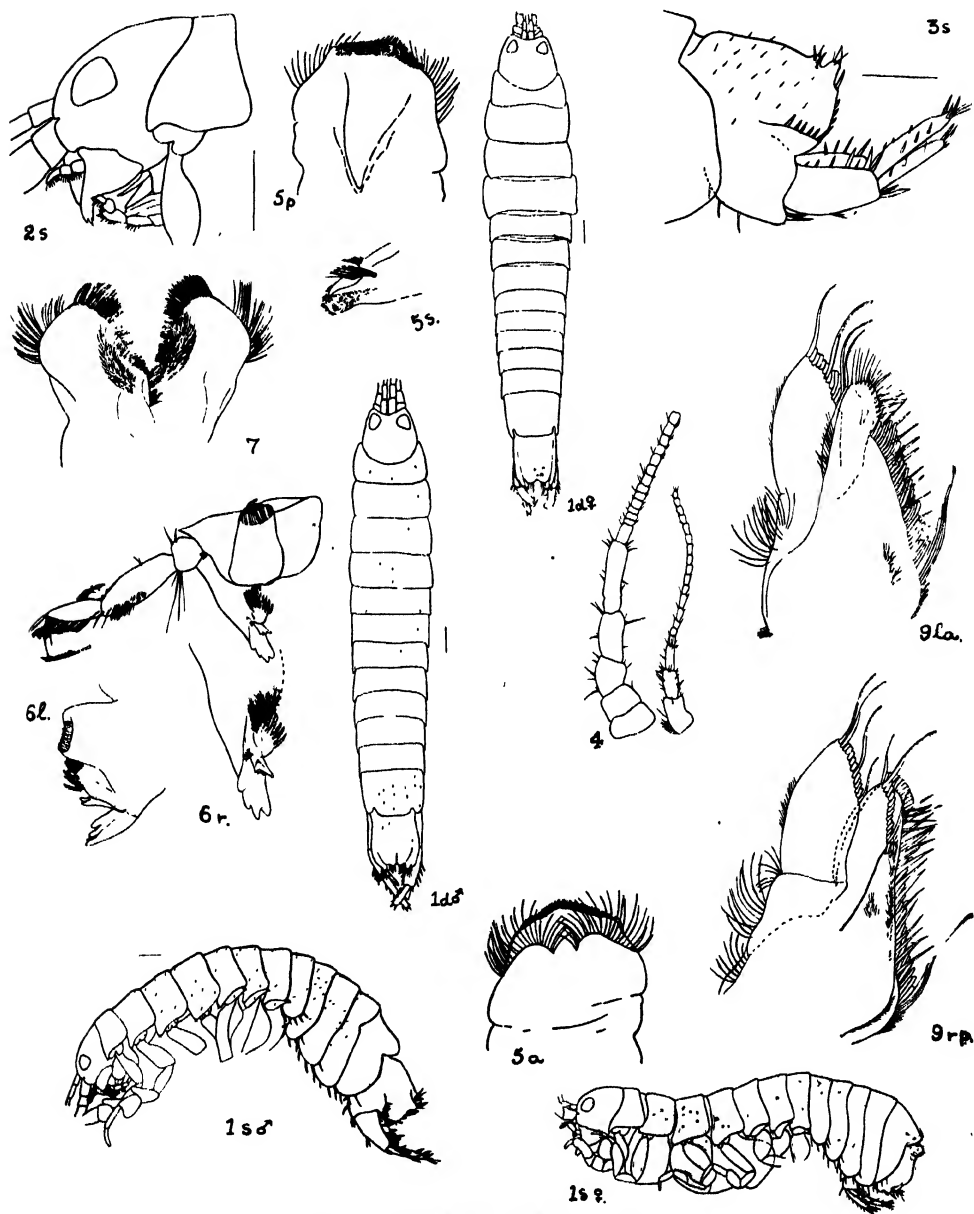


FIG. 18.—*Amphisopus lintoni* (Nicholls).

cephalon and peraeon, first to fourth segments sub-equal in length, fifth segment meeting its pleuron behind in a deep notch, as long as the combined length of the third and fourth; tailpiece (fig. 18, 3) large; median projection lacking, the transverse postero-dorsal border slightly arched, with shallow rounded emargination, the margin of telsonic pleura deeply notched and raised into three well-marked paired prominences, each crowned by a stout movable spine. The suture between sixth pleon segment and telson is well developed and at its posterior end bears several stout and movable spines. Anterior to the uropod, the pleuron of the sixth segment has its margin armed with from four to six spines and spinules.

*Antennule* (fig. 18, 4) longer, relatively, than in any other Phreatoicid, flagellum extending to sixth joint of flagellum of *antenna*, with as many as eighteen short joints, which widen distally. The *antenna* equals the combined length of the head and the first six peraeon segments, or rather more than twice the length of the antennule, peduncle with first joint very short, second and third stout and sub-equal, fourth nearly as long as first and second combined, the more slender fifth almost equalling the combined length of third and fourth; the flagellum, once and a half as long as the peduncle, may have thirty or more joints, the first being short. The fur-like covering of fine setae found in *palustris* is wanting in this species.

The mouth parts differ in many details from those of *palustris*. The labrum (fig. 18, 5) broader than deep, its ventral edge densely fringed with very short setae, while across its anterior aspect is an interrupted rank of long setae; *mandibles* (fig. 18, 6) with palp relatively short and stout, second joint half as long again as the third and greatly widened; all joints setose, many setae pectinate, the rank on the third joint stretching along most of the length. On the right mandible, both the principal cutting edge and that on lacinia mobilis bear four teeth; those on the lacinia being minutely denticulate; a row of plumose setae lies dorsal to the spine row and one or two free setae arise from the molar surface; *lower lip* (fig. 18, 7) shows a relatively great development of the latero-distal tuft of setae and a number of setospines occur on the mesial border. The inner endite of the *maxillula* (fig. 4B) is widened distally, its rounded end with from seven to nine setospines; outer endite, with one small setospine near the inner end of the row of teeth, and two sub-terminal plumose setae on the posterior face of the endite.

*Maxilla* (fig. 18, 9*la*), examined from in front, the proximal endite appears sub-triangular, very wide at its base; it is scarcely divided into proximal and distal parts; the mesial surface narrow, the entire length of its anterior edge occupied by the usual continuous row of filter setae which reaches the end of the proximal part of the endite and passes onto its anterior surface. Just proximal to these filter setae there is a short fringe of simple setae, and upon the anterior face of the endite, nearly level with these, is a small tuft of similar setae, but the continuous line of setae anterior to the filter setae, present in some species, is wanting in *lintoni*. The posterior ridge (fig. 18, 9*rp*) bounding the mesial surface is armed by stout, widely-spaced, biting setae, varying in number from nine to fourteen, and extending to the inner edge of the apex. Parallel to these, on the posterior face of the endite is a shorter fringe of simple setae. These in the distal part of the endite spread out and cover much of this surface—they are hidden from view in the figure by the inner of the two distal endites. The outer edge of the inner endite is fringed with long, simple setae. The inner of the two distal endites is short and narrow, its very obliquely truncated apex bearing a single close-set series of biting setae. The outer endite is broader and similarly armed. Its lateral border has a distal fringe of setules, and proximally, from the bases

of the second and third segments, arises a whorl of long setae. Still more proximally is another short fringe of setules.

*Maxilliped* (fig. 19, 10). This is remarkable, in the male, for the presence of a stout setose lobe on the coxa, resembling that of the immature female of other species, and for the development on the postero-mesial surface of ischium, merus, and carpus of a pilose area thickly crowded with setules. The distal end of the basis shows a trace only of this condition, but ventrally it bears a small group of plumose setae; on the endite of the basis, the fringe of brush setae stretches for two-thirds of the length of the dorsal edge of the endite and passes apically into a series of simple setae which are continued along the ventral edge in a line of biting setae; the distal border of the ischium has a fringe of plumose setae; the merus is produced almost to the distal end of the carpus, much of its distal margin bearing an edging of simple setae; the dactyl is practically devoid of setae along its outer margin. In the ovigerous female, the coxal lobe is large and bears a number of short plumose setae distally; more proximally the setae are curved and may bear one or two barbs apically. The epipodite is large, sub-circular, with a mesial border of setae and a few apical setae.

As compared with species of other genera, the *peraeopods* are relatively short; in all, the coxae are fused with their related segments in both sexes; the hand of the gnathopod (fig. 19, 11), which does not differ greatly in shape in the two sexes, attains, however, a much larger size in the female, and is more widened basally. It has the propod sub-triangular, the palm meeting the posterior margin in a rounded prominence which is markedly setose and more pronounced in the female, the distal portion of the palm being concave, the dactyl long and stout. The dactyl has a large sub-terminal spine in both sexes, but otherwise the armature of the dactyl differs markedly, being denticulate in the female and armed with close-set setae in the male. In the male, moreover, there is found a pilosity of the hinder surface of ischium, merus, and carpus which is even more pronounced than in the maxilliped. A similar development is found in the male on second, third, and fourth *peraeopods*; but in the female this condition is not developed, the second, third, and fourth being much as in *palustris*. In the male, the fourth *peraeopod* (fig. 19, 12(4)) is modified probably to a greater degree than in any other genus of Phreatoicoidea, the carpus, as well as propod and dactyl, being involved in the clasp; the ischium and merus are expanded, the latter strongly (approaching the condition of these joints in *Eophreatoicus*), the carpus also is widened, but the propod is curved and narrow and rounded apically. The dactyl, which widens distally, projects from the *anterior border* of the propod and acts, with that joint, as a single curved piece, folding against the strongly setose posterior border of the carpus. A tiny spinule represents the vestige of the secondary unguis.

The coxal joints of fifth, sixth, and seventh *peraeopods* are visible externally, a definite groove indicating the suture with the pleuron of the related segments; they have become flattened plates which have taken on the colouring and marking of the adjacent pleura; the bases are more strongly expanded than in *palustris*, but unarmed anteriorly; the succeeding joints have strong spiniform setae, occurring in tufts and more numerous than in the corresponding appendages of *P. palustris*, while the posterior border of the joints is produced into strong spines which may be very conspicuous.

The male appendage usually comes away with the seventh *peraeopod* if the coxal joint is also detached; it differs little from that of *palustris*.

The ventral margin of the first pleon segment is rounded, the anterior part of the curve with about six setae which become spiniform, while the more posterior part of the margin, in this and the following pleura, is set with short hair-like



setae rather widely spaced; the second pleuron has a similar short, gently convex, inferior margin with one or two spiniform setae anteriorly, while on the postero-inferior angle are several stronger setae, the intervening space being fringed with fine hair-like setae more closely set than those which continue onto the posterior margin; the third and fourth differ little except that they are broader and there is a posterior rounded angle; the fifth has a broadly-rounded inferior margin which, except for a couple of stiff setae anteriorly, bears only close-set hair-like setae.

In life, the *pleopods* are clearly visible, below the pleura, the greater relative length being partly due to the largely-developed sympodite. In the male, the exopodite of the first pleopod (fig. 19, 13(1)) has a strongly curved transverse fold corresponding to the great curve of the penial stylet; plumose setae are practically confined to the distal half and are numerous and close-set, a fringe of short, fine setae, or variably, one or two plumose setae edging the excavated proximo-lateral border; some long simple setae are scattered over its anterior face distally. The endopodite is short and may be emarginate, almost bi-lobed; the mesial border of the sympodite is produced into a short flange on the straight edge of which are the numerous coupling hooks (fig. 19, c.h.). The inner edge of this flange seems to be bent upon itself, almost at right angles and the hooks, for the most part, arise just within the margin and are thus likely to be overlooked unless careful search is made, whereas in *A. annectens* and *P. palustris* some or all of the hooks project well beyond the free edge. The second pleopods (fig. 19, 13(2)) are scarcely wider than the first, the exopodite produced into a small and narrow latero-proximal lobe almost devoid of setae, as well as being divided into proximal and distal plates bearing plumose setae. On the lateral border these plumose setae extend some distance proximally, but, on the mesial border, they are almost wholly replaced by long, simple setae, which extend nearly to the proximal end of the plate; the lamellar lobe of the endopodite is relatively smaller than in the corresponding appendage in *P. palustris*, but the basal segment is stout and well developed and gives rise to a very strong penial stylet which has the shape characteristic of the Amphisopinae, strongly curved and tapering to a flattened pointed apex. Along its inrolled mesial edge is a row of short, stiff setae, comparable to, but fewer than, those found in *Mesamphisopus* and *Eophreatoicus*. On the sympodite, the coupling lobe is smaller than in *P. palustris* and is rounded and knob-like with but three coupling hooks and with one stiff seta; the lateral aspect of this sympodite is produced into a thin flattened plate, better developed than in *palustris*, and is armed with a single stout spiniform seta distally. On the remaining pleopods, the sympodite is narrower, lacking this lateral extension, but in its place springs the epipodite, sub-triangular with rounded angles, attached by a narrow base and fringed with long, simple setae which are much more closely set on the mesial border. In the third pleopod, both exopodite and endopodite are broader, the former produced proximally as in the preceding appendage into a well-developed proximo-lateral lobe lying immediately posterior to the epipodite; the endopodite extends ventrally nearly to the insertion of the distal plate of the exopodite and springs from a short proximal muscular segment; the coupling lobe is smaller and angular and bears but a couple of setae. The endopodite narrows slightly in the fourth and considerably in the fifth, the epipodites decrease in size, the coupling lobe becoming longer and narrower; in the fourth it bears several setae and is reduced in size.

In the female, the first pleopod (fig. 19, 13(1) ♀) is unmodified, it has exopodite and endopodite much more nearly equal, both lamellae being narrower and sub-acute, the exopodite densely fringed distally along both borders with plumose

setae and mesially, in the proximal half, with short, simple setae. Laterally, the border is not excavate and there are a few widely-spaced simple setae. On the anterior face of the lamella are scattered, stiff, simple setae, principally in its lateral half, more numerous than in the male. The endopodite is larger, relatively, and shows no modification into distal and proximal portions. The sympodite bears fewer coupling hooks. The second pleopod differs from those following chiefly in that it is narrower and lacks an epipodite.

The ventral pleural margin of the sixth pleon segment (fig. 18, *3s.*) is very short, the almost vertical anterior margin meeting it in a steep curve upon which is one short spiniform seta followed by four to six spines increasing in size to the most distal which underlies the insertion of the uropod. Immediately adjacent to this spine dorsally is a close brush of fine setae, elsewhere lacking from this margin. The postero-inferior part of the tailpiece ventral to the dorso-lateral notch (the telsonic pleuron) is broadly convex, but its margin is raised into three prominences about equally spaced, each crowned by a very stout spine; in the intervening gaps are setae which may be spiniform, the border distal to the last of these spines and dorsal to the actual insertion of the uropod bears two or more spiniform setae and other finer setae. Above the dorsal angle of the insertion of the uropod, a short rank of three to five very stout spines dorsally directed marks the suture of sixth pleon segment and telson.

The peduncle of the *uropod* is stout, in transverse section sub-triangular, both inner and outer faces curved, meeting in a rounded edge below, which appears smooth, but on closer examination reveals the presence of several spinules, usually three, each of which may be associated with one or more fine setae. These are borne slightly laterally, and may be folded down, in which condition they are easily overlooked. The ventral distal angle beneath the origin of the outer ramus is occupied by a stout spine (fig. 19, *15*) with its end obliquely truncated, the oblique dorsal face toothed. Mesially to this, and in lateral view hidden by it, is a shorter but similar spine, and externally, a third. Such toothed spines in this position occur also in *Synamphisopus*, but are otherwise confined to the Phreatoicinae, no member of that sub-family being without them, except the two species of the genus *Phreatoicus* s.s. The dorsal face of the peduncle is concave forming a deep groove, narrow proximally, but widening distally. The curved dorso-lateral border, fringed with about eight spines, slopes downwardly to a point but little above the ventro-distal angle. The strongly-curved mesial edge, on the contrary, rises dorsally to an angle well above the level of the insertion of the inner ramus. It bears about five stout spiniform setae, and, at its postero-distal angle, two spines separated by a stout spiniform seta; the distal spine is stout and long, being nearly half the length of the outer ramus. Both rami appear rounded but are actually slightly concave dorsally, the inner, which is rather the longer, is as long as the peduncle, has its margins armed by four pairs of spines interspersed with finer setae, its obliquely truncated end having two long and one shorter spines and a sub-terminal tuft of very fine setae. The outer ramus is rather more slender and likewise has four spines, while terminally are one shorter and one very long spine, the latter extending just to the end of the inner ramus; there are, in addition, several terminal spinules, apparently variable in number.

**Colour.** Variable, dark grey to chestnut brown, mottled or marbled and banded.

**Size.** Largest female taken 20 mm.; largest male 13.5 mm.

**Habitat.** On submerged stakes or snags or under vegetation growing in water—many localities around Albany, W.A., and east as far as 'Two-people Bay'.



In this district one specimen was found in the pitcher of *Cephalotus*; it is apparently strictly coastal—some localities at Albany being within a few yards of the sea—as is the case with some New Zealand surface-living forms.

*Amphisopus annectens*, sp. n.

(Figs 20, 21)

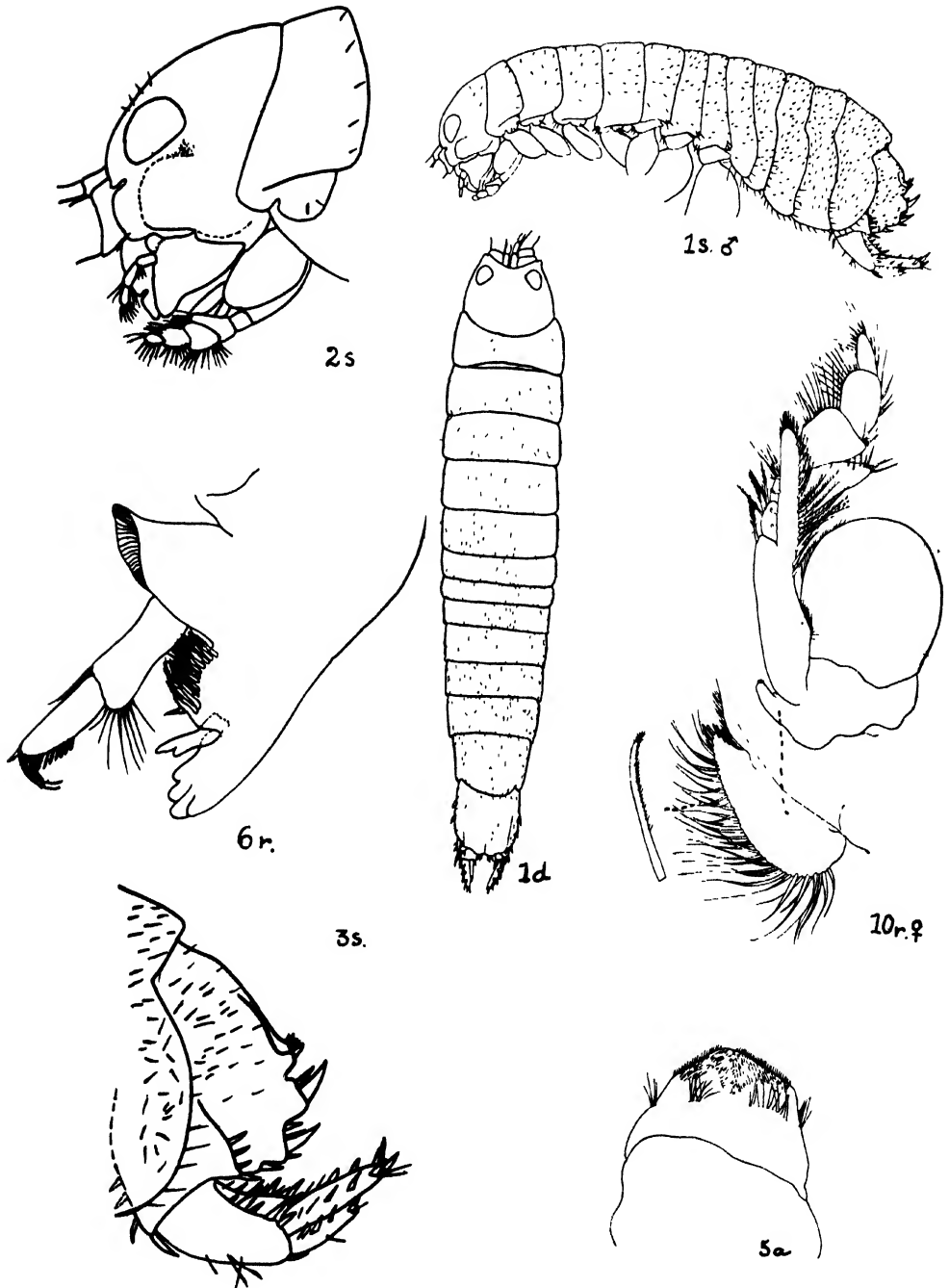
Like *A. lintoni*, from which it differs in most of the following characters: It is a much smaller species, the body more slender, with abundant scattered setae; eyes of moderate size (with about fifty ocelli), separated by less than twice the long diameter of the eye; cheek notably scaly. All of the segments in the peraeon show setules sub-marginally along the hinder border; the pleon is shorter, having, with the tailpiece, a length almost two-thirds of that of cephalon and peraeon combined; all pleon segments having posterior margin slightly excavate, that of the fifth being deeply notched, the ventral and posterior edges of the pleura being armed with spaced setae.

The telsonic apex is very slightly emarginate, the emargination angular, while from the mesial side of the notch on either side of it, the lateral ridge is armed with setae; two relatively immense spines rise from the posterior border just below the level of the dorso-lateral notch, followed by a number of spiniform setae of various sizes on the postero-inferior margin; the suture between sixth pleon segment and the telson bears two or three strong spines and, more posteriorly, a spiniform seta, the inferior margin of the sixth pleon segment being armed posteriorly with a stout spine preceded by a smaller spine and two spinules, while the whole of the vertical anterior margin is densely fringed with fine setae.

The *antennule* is little longer than the peduncle of the antenna, its flagellum having thirteen joints which are not noticeably widened distally; the antenna is nearly two-thirds of the length of the body, the flagellum with relatively few (about twenty) joints.

The rank of long setae across the outer surface of the upper lip (fig. 20, 5a) runs in a very broken line, being much less complete than in *lintoni*.

On the *right mandible* (fig. 20, 6r) the lacinia mobilis is very slight and transparent, the spine row followed by a series of plumose setae or slender seto-spines; the palp with fewer setae; the apex of the inner endite of the *maxillula* is obliquely truncated and has eight setospines which tend to spread onto the mesial border. At the proximal end of the inner endite, the *maxilla* has a short anterior row of simple setae, not observed in *lintoni*; the endite is scarcely divided into basal and distal portions and the row of filtratory setae passes nearly to the apex, while the posterior sub-marginal row of pectinate setae (about fourteen) passes onto the posterior face, short of the apex; lateral to these distally is a short line of simple setae; all the apical spines on the distal endites are stout, but on the inner of the distal endites are one or two particularly strong denticulate spines. The *maxilliped* (fig. 20, 10r) shows a small coxal lobe which is slightly setose in the immature female and markedly setose in the ovigerous condition; it may be present, also, though much smaller and unarmed, in the male; the basal endite carries brush setae along practically the whole of the dorsal edge; a fringe of setae springs from the outer border of the dactyl. Between, and anterior to, the maxillipeds a median process is strongly developed. The pilosity found in the male of *lintoni* on several joints of this appendage and on the gnathopod and fourth peraeopod is not apparently developed in this species. The palm of the gnathopod (fig. 21, 11) is concavo-convex, the convex posterior part

FIG. 20.—*Amphisopus annectens*, sp. n.

armed with long setae in the female; in the latter the dactyl is strong, its palmar edge bearing a series of stout teeth. The peraeopods are slender, the fourth (fig. 21, 12(4)♂) in the male modified perhaps even more obviously than in *A. lintoni*; it is apparently not used in walking, and its basis is not expanded. Instead of the pilose area on the posterior surface, the propod of the fourth peraeopod in the male in this species has developed a curious granulation of the anterior aspect of this joint. The coxae of the fifth, sixth, and seventh peraeopods are well defined, the bases (fig. 21, 12(7)) expanded, the anterior border of the joint being markedly setose, the posterior having a few scattered setae; in the seventh the hinder margin of the basis is irregularly crenate and the 'inferior notch' well developed; upon the bases of all three of these appendages there are scattered setae on the outer surface.

In the first pleopod (fig. 21, 13(1)) there is found the development of simple setae over much of the anterior face of the exopodite in the female, and more distally in the male; in the latter the fringing setae on this lobe are bushy and the lateral excavation of the exopodite and the curved fold across its face are also very marked; coupling hooks are particularly well developed on this, but are fewer on the second pleopod; in the second and third these are borne on an outstanding coupling lobe, and in the third and succeeding pleopods the hooks decrease in number, but may be followed by short setae; the proximo-lateral lobe of the second pleopod is fringed with short setules, much of the more distal border being unarmed, while plumose setae extend for one-fifth of the mesial border of the exopodite. A feature of the second pleopod (fig. 21, 13(2)) in the male is the remarkable development of the peduncle of the endopodite, while the penial stylet is very strong. In the third pleopod, the long setae on the epipodite are finely pectinate, those on the exopodite plumose, but these do not reach the proximal end of the lamella on either border. The first pleopod is the shortest; second, third, and fourth are longer, the fifth somewhat shorter than the fourth (in these proportions resembling *australis* rather than *lintoni*).

The uropod (fig. 21, 15) has a rather stouter peduncle, relatively shorter than that of *lintoni*, its inferior border with two or three tufts of setae, its disto-mesial angle less produced into the usual shallow, blunt process armed with spines, of which only one is long; the inner ramus is as long as the peduncle, and is furnished with spines as in *A. lintoni*; the outer ramus is relatively shorter with one terminal spine, unusually stout. Beneath the insertion of the outer ramus are one stout and a second and third more slender, toothed spines, much as in *lintoni*. Higher on the inner distal end of the peduncle, are one or more slender toothed spines—evidently a vestige of the series of such setae in this position in *Hyperoedesipus*.

*Colour.* Light to dark grey, the colour varying with the abundance of dendritic black chromatophores on a pale cream-coloured background.

*Size.* The largest specimen obtained measured about 10 mm., males and females being of equal size; females of just over 5 mm. are found with incipient brood-pouch; the number of embryos found in the pouch apparently not exceeding fifteen.

*Habitat.* A single specimen was taken (December, 1927) in a foliose *Jungermannia*-like liverwort around the mouth of a spring which gushed out in boggy land, just on the edge of well-grown Karri forest about seven miles south of Pemberton, West Australia. In July, 1928, a number of others (of which a few were kept alive in the laboratory until the following December) were secured in the surface mud along the banks of a drain issuing from the bog, on this occasion associated with a large *Neoniphargid*.

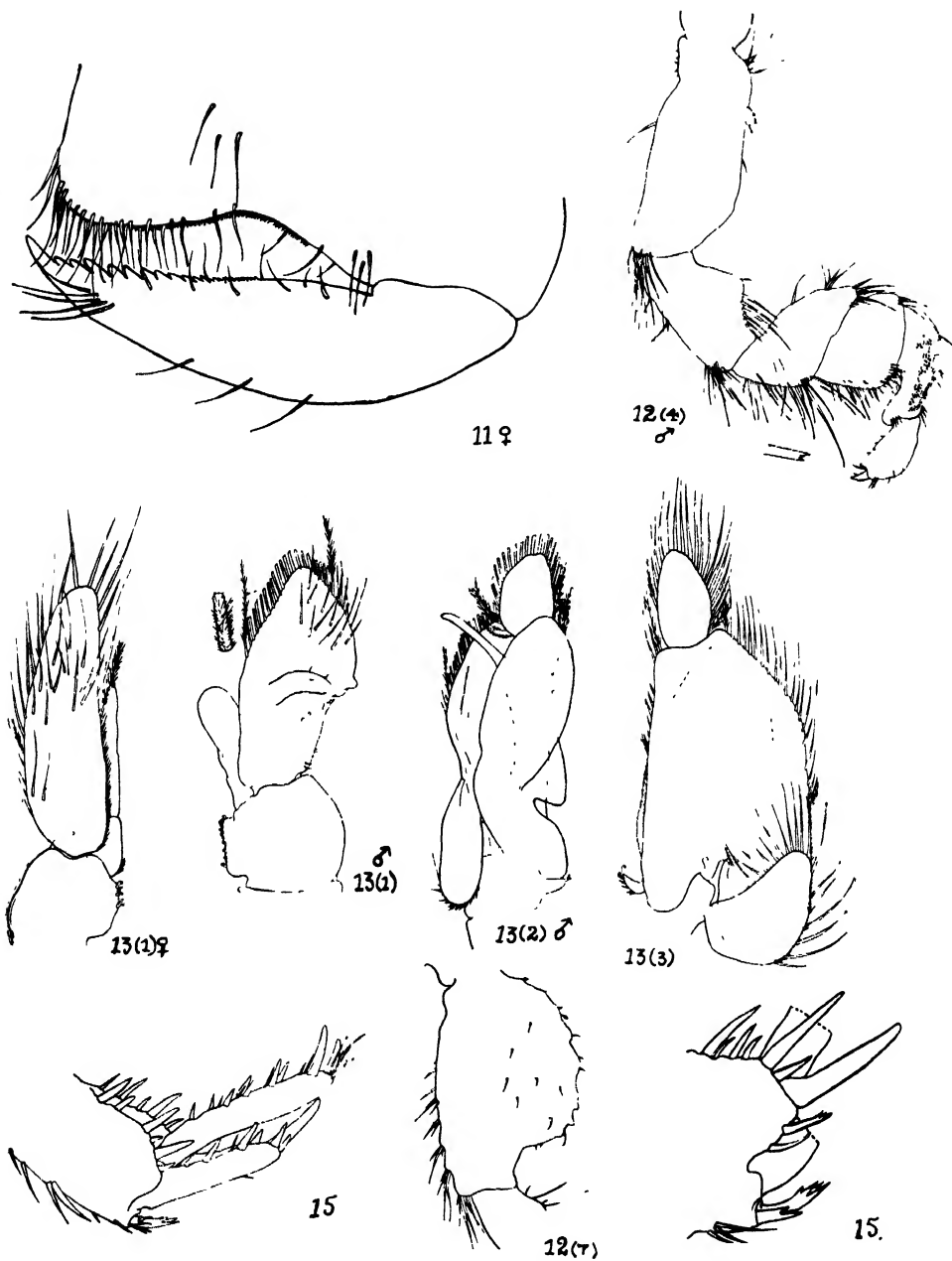


FIG. 21.—*Amphisopus annectens*, sp. n.

Co-types are lodged in the collection of the Museum, Perth, W.A.

In the period 1930-1940, two other Amphisopids have been taken in Karri forest country—both of these having been provisionally referred to this species. Material is too scarce for sufficiently detailed study, but it seems probable that forms from these two localities will prove to be distinct. One was collected from small patches of sphagnum in dense forest country about forty miles south-west of Manjimup, that is, about twenty-five miles in a direct south-easterly line from the type locality for *annectens*. The creek along the banks and in the bed of which the sphagnum occurs may possibly flow into a tributary of the Deep River; it is separated from the Warren region by the Shannon River system.

Nearly forty miles farther to the south-east, at Walpole, near the junction of the Frankland, Walpole, and Deep Rivers, is another small swamp from which the third form has been taken sparingly. In the seventy or more miles between Walpole and Albany no trace of Phreatoicid has so far been found.

### Sub-family III. PHREATOMERINAE

Body depressed. Head small, without cervical groove, almost embraced by first peraeon segment which is short, but greatly produced antero-ventrally and fused with head, except for a free margin; eyes large and prominent. Peraeon greatly widened, greatest width (in the female) nearly equal to half the length of body; telson with narrow median incisure. Antennule relatively long, filiform; antenna short. Peraeopods, with coxae greatly reduced, one to three prehensile, two and three feebly sub-chelate; basis, ischium and merus expanded; fourth peraeopod not sexually modified; bases of hinder peraeopods greatly expanded, dactyl long. Pleopods with lamellae oval, relatively wide, sub-equal, with anterior face of exopodite armed with a number of short ranks of stiff pectinate spines; with coupling hooks on sympodites of first to fourth pleopods; both first and second pleopods modified in male; penial stylet very stout, strongly curved, unarmed. Uropods, with rami truncated and continued by freely movable terminal spines. With very large number of embryos in brood-pouch.

*Phreatomerus*, the only genus included here, is probably the most specialized and least typical of surface-living Phreatoicids. The condition of the head is unusual; the depressed peraeon, which may reach a width equal to one half, nearly, of the total length of the body and is followed by a pleon appearing strongly compressed, constitutes an ensemble which has no parallel in Isopoda. The telson is unique in the sub-order, if not in Isopoda, in being cleft.

It survives in the arid region, an area which, in Cretaceous times, was submerged by the sea, and to-day it is found in the strongly-flowing, hot, and slightly salt water—the overflow from a bore of comparatively recent date. Clearly, there must be hide-outs in this arid country, where it has managed to persist and from which it has reached the bore overflow, so that a search in this region will probably reveal other species. Its relationships seem about equally with *Paramphisopus* and *Phreatoicopsis*.

### *Phreatomerus* Sheppard

Head very short, embraced by first peraeon segment, sub-ocular incisure on head clearly indicated; cervical groove wanting; peraeon broad, depressed, the pleura being greatly developed and out-turned; pleon moderately compressed; telson incised, not produced into terminal projection. Antennule relatively long,

much longer than peduncle of antenna. Coxae of first to fourth peraeopods hidden beneath the downwardly produced pleura of their related segments to which they are immovably united, except in the female in which the second, third, and fourth coxae are apparently free; while those of fifth to seventh peraeopods are completely fused with related segment in both sexes; gnathopod of male and female alike, except for difference in size. Second, third, and fourth peraeopods with terminal three joints involved in grasping mechanism; fourth peraeopod of male not sexually differentiated; bases of three hindmost peraeopods exceptionally expanded and dactyls very elongated; posterior margins of pleon segments with sparse setal fringe; pleopods with lamellae sub-equal sympodite on all pleopods bearing mesial coupling lobe with entangling setae and coupling hooks; both first and second pleopods modified in the male; suture between last pleon segment and telson strongly developed; peduncle of uropod with mesial distal process strong, spine beneath insertion of rami of uropod stout and simple, rami slender with movable terminal spines.

Genotype. *Phreatomerus latipes* (Chilton).

### *Phreatomerus latipes* (Chilton)

(Figs 22, 23)

Chilton, 1922, p. 23, and 1924, p. 9 (*Phreatoicus latipes*).

Nicholls, 1924, p. 92 (*Phreatoicus latipes*), and 1926, p. 182 (*Amphisopus latipes*).

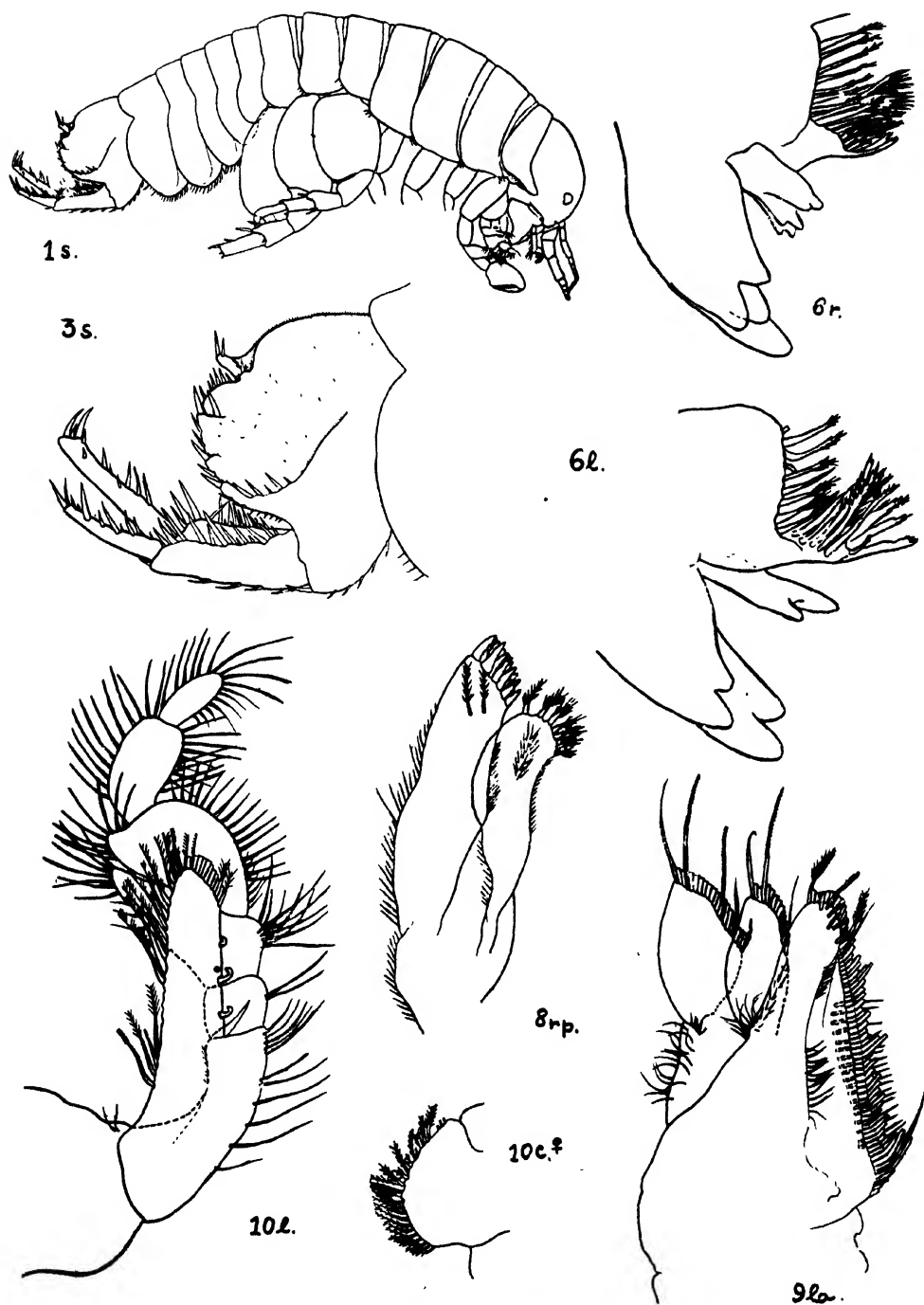
Glauert, 1924, p. 161 (*Phreatoicus latipes*).

Sheppard, 1927, p. 113 (*Phreatomerus latipes*).

Hale, 1929, p. 326 (*Phreatoicus latipes*).

As is shown in Chilton's figure (1922, p. 27, fig. 1), the animal can roll up almost as completely as a Sphaeromid or an Armadillid. The body is stout (with slight wrinkles and irregularities on most segments) its surface appearing nearly smooth. Actually, it is scaly and, in the posterior region particularly, bears a number of fine short setae. It is so strongly depressed and so broadened that its length is little more than twice its greatest width. The head is flattened and, unique in this sub-order, appears sub-pentagonal as seen from above; is rather wider in the male than the female; it is notably concave anteriorly with a distinct median vertical ridge (rostrum?) and, again peculiar among Phreatoicids, extensively embraced laterally by the first peraeon segment. Its dorsal surface is strongly sculptured, the eyes black, large, and very prominent with numerous ocelli (80 or more). The cervical groove which is so well marked in the Phreatoicidae where it runs vertically upwards from the ventro-lateral border of the head, near its hinder edge, seems here to be completely wanting, unless a short groove exposed upon the side of the head, *ventral* to the forwardly produced and outwardly projecting pleural flap of the first peraeon segment, may represent the last vestiges of this suture. If the projecting part of this first peraeon segment be cut away, the groove can be traced for some little distance dorsally. If this groove in *Phreatomerus* really represents this suture, it is unusually forwardly displaced, but in any case the anterior border of the first peraeon (gnathopod) segment has here moved forwardly more than in any other Phreatocid into the plane of the immediately anterior segment, almost wholly concealing the post-mandibular part of the head.

The length of the peraeon is practically one-half of the total length of the body; it is broad, strongly depressed and only moderately convex, all the segments from the second to the seventh having a slight transverse groove which

FIG. 22.—*Phreatomerus latipes* (Chilton).

divides them into very unequal parts, the smaller anterior band being almost wholly overlapped by the preceding segment when the animal is extended; the pleural portion of the first four peraeon segments is produced outwardly and slightly downwardly so that, in dorsal view, it conceals not only the coxa but, also, about the proximal third of the basis. The first peraeon (second thoracic) segment is very short in the middle line but greatly expanded laterally and is immovably joined with the head, the suture being well marked and the lateral pleural border turned outwardly, producing, in ventral view, the effect of an extensive thickening. Anteriorly, it is produced nearly halfway along the ventro-lateral region of the head to which it is firmly attached and immovable; although having an appearance of freedom, actually only the anterior projection of the epimeron is free; the second, third, and fourth segments are also forwardly produced but less strongly, each underlying the segment preceding. Owing to their great lateral expansion, these three segments appear in side view (fig. 22, 1s) as much deeper than the segments which follow them. The pleon is relatively short, narrow, and scarcely more than half of the total length of the cephalon and peraeon. It appears laterally compressed, and the pleura are greatly produced (in the fourth and fifth segments almost twice the depth of related segment). The anterior and posterior borders, which are in some segments sparsely fringed with long setae, meet in a rounded angle, so that an inferior margin is absent, but a ridge runs dorsally from the ventral end more or less parallel to the anterior border, marking off a narrow anterior area. In the hindermost pleon segment a wide (re-entrant) angle marks the junction of the pleuron with its related segment. The sixth is united with the telson, but the suture, which in other members of the sub-order has been interpreted as the vestige of its posterior boundary, is here a well-defined ridge which traverses the entire tailpiece, reaching almost to its anterior border (fig. 22, 3s). The telson is strongly arched above and the convex posterior border is unique in this sub-order in being incised. It is fringed with spines and setae.

The *antennule* (fig. 23, 4) is relatively long, varying from three-fifths to two-thirds of the length of the antenna (in the male barely half), its peduncle with first joint broad and long, very setose, second barely two-thirds of length of the first (or of third), third slender, not quite as long as first, followed by a flagellum of nine joints (female) or ten (male) which is very slightly longer than peduncle; there is an olfactory cylinder on the end of the sixth to ninth segments accompanied by sensory setae of slightly different type and with a bunch of these latter terminally. The *antenna* is stout and unusually short, approximately one-fourth of the length of the animal, with first joint of peduncle very short, second slightly longer, third and fourth sub-equal, each about as long as combined length of first and second, the fifth half as long again as the fourth and less stout than the four more proximal joints; the flagellum, as long as the peduncle, may have as many as twenty-two joints, all setose, the more proximal joints being stout (as broad as long) the terminal more slender.

The mouth parts are stout and, in general, resemble more closely those of *Phreatoicopsis* than of *P. australis*, to which Sheppard and Chilton compare them. The upper lip, which is strongly asymmetrical, has the lateral tuft of setae, so characteristic of many Amphisopine forms, well-developed.<sup>(1)</sup>

The *left mandible* (fig. 22, 6l) shows the cutting edge stout, dark, and heavily chitinized, with four strong teeth; *lacinia mobilis* well developed with but three teeth. The spine row is prominent and is followed by about eight ciliated setae;

(<sup>1</sup>) Lacking in *E. kershawi* and *M. capensis*.



on the opposite appendage the lacinia is less stout and its three teeth appear bifid. The molar is long, its surface very oblique. The palp is short, the third joint armed with a double row of setae, one row with setae pectinate along one edge, the other simple setae.

The lower lip is stout, the outer lobes not quite so incurved as in *Phreatoicopsis*, with a dense terminal tuft of long setae, the inner lobe fringed with a fur of very short setae; the outer border has the characteristic detached tuft, and near the base, these setae becoming very short and obliquely set.

The maxillula (fig. 22, 8) has seven or eight (rarely six) setospines at the apex of the inner endite, the outer endite about twelve or thirteen spine-teeth, the four most laterally placed long and curved, the rest shorter and so coarsely pectinate as to suggest denticulation; both the outer and inner borders of the distal endite and inner edge of inner endite are fringed with long fine setae, but the outer border of this latter endite is almost devoid of setae.

The maxilla (figs 22, 23, 9) agrees very closely with the description given for *P. palustris*; the setae on the apex of the proximal endite are very crowded, the inner distal endite is rather slender but the outermost is quite short and wide, with fifteen or more setae (Sheppard says nine or ten, a statement based, perhaps, on immature or juvenile material).

The maxilliped (fig. 22, 10) is more heavily setose than in any other Phreatoicid, with the exception of *Synamphisopus*—a condition which might be supposed to be related to its mode of life (free swimming in open waters) were it not for the fact that a relatively high degree of setosity is found also in *capensis*, *annectens*, *tasmaniae*, *Notamphisopus*, spp., and *australis*, all of which, except *tasmaniae*, have a comparatively sheltered habit of life beneath stones or encrusting vegetation. In still more sheltered habitat, however, as, for example, in underground waters, this setosity tends markedly to decrease. It seems probable, therefore, that such setosity was a primitive characteristic. In many specimens, these setae were thickly encrusted (as, is frequently the case, in *Phreatoicopsis terricola*) with infusoria. The epipodite, shallowly convex, is in outline almost circular, its mesial distal border edged with fine setae (omitted from Sheppard's figure—1927, fig. 1 (4)); the basis is curved, rather narrow, considerably more than twice as long as broad, its mesial border sparsely setose with one terminal tuft of long setae; the merus produced laterally and distally almost as far as the distal end of the carpus, with its internal border markedly convex; it is free from setae only for a short part of its latero-proximal border; the carpus has its mesial border very convex, its outer distal angle barely projecting beyond the merus, all of its free border fringed with long setae; both propod and dactyl are a long oval in shape—the dactyl much the narrower, with a practically continuous fringe of setae. From the basis, the endite projects as far as the inner distal border of the merus, its rounded apex set with long brush setae which continue, as more sparsely feathered setae, along its dorsal edge nearly to the proximal end of the plate. The small lobe upon the coxa of the maxilliped in the female is, prior to the development of the brood-pouch, a stiffly projecting setose flap, median and vertical in position. At its fullest development, it is enlarged and becomes bent obliquely outwards, in a medio-lateral plane within the brood-pouch, its concave surface directed mesially, its border fringed with long recurved setae, many of which are plumose. Together, these setae form a strainer-like fringe which fills in the tiny gap between the mesial borders of the anterior lobe of the first pair of oostegites. From their disposition, it seems improbable that these can function (as Miss Sheppard suggests) in producing the aerating current through the brood-pouch, the flaps being more or less secured in place by the pressure of the

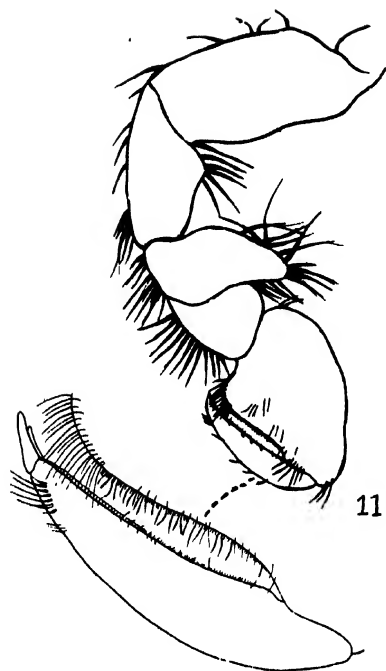
first pair of oostegites. It would seem that this current might be indrawn anteriorly by the action of the pleopods which swing in a well-defined channel bounded by the pleural walls, and which are natatory as well as branchial, but in living forms examined no appreciable ingoing current was discovered. It appears probable that these setose lobes upon the maxillipeds are strainers only, although they may perhaps serve to shift the eggs.

*Peraeopods.* The notably depressed condition of the peraeon is due in part to the actual broadening of the body in this region (cf. Chilton, 1922, fig. 2)—this being even more evident in the female. Associated with this, is a very definite outward development of the pleura of the first four peraeon segments, so that these latter present a large ventro-mesial surface (instead of a ventral edge which is the practically invariable condition in other Phreatoicids). In the case of the first peraeon (second thoracic) segment, it presents an actual ventral surface, triangular in shape and concave as seen from below. Related to this modification, the coxae of the peraeopods of these segments have coalesced with the pleura and are completely hidden in side view—but seen from below are bent inwards towards the mesial border of these pleural surfaces. The bases (relatively shortened and broadened) are, also, overhung in some cases for more than a third of their length.

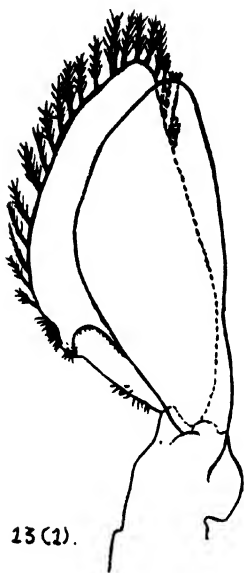
*Gnathopod* stout, strongly sub-chelate, propod sub-triangular, smaller in the female, palm straight and (alone amongst Phreatoicids) entirely free from spines or denticles; in place of these the palm is setose and bears between the setae, a continuous fringe of setules; the palmar edge of the dactyl seems incised, forming an edging of short blunt spinules; these, which line the distal half of the dactyl in the female, are more restricted in the male. There is a group of two or three spinules antero-proximal to the base of the dactyl (fig. 23, 11), and the dactyl bears a stout secondary unguis. The second, third, and fourth peraeopods are similar (except for the hand) but more slender than the gnathopod, with posterior border of carpus and propods densely set with stout setae, the propod narrower and the dactyl exceptionally elongated, secondary unguis present; all three appendages obviously capable of a strong grasp, the tip of the dactyl, when clenched, burying itself in the setal fringe of the merus; the fourth in the male not differing from that of the female, but with propod longer and more slender than in second and third. In this unmodified condition of the fourth peraeopod in the male, we have, perhaps, a primitive condition shared with *Phreatoicopsis*, *Eophreatoicus*, and *Paramphisopus*, departed from in *Amphisopus* and *Mesamphisopus* and, in a different fashion, by *P. typicus* slightly and in other Phreatoicids very markedly. The fifth, sixth, and seventh peraeopods are alike, but increase progressively in length of limb and degree of expansion of basis in which latter feature they reach a development attained by no other extant Phreatoicid and approaching rather nearly the condition seen in the extinct *wianamattensis*. The expanded part of the basis consists chiefly of a thin plate defined from the rounded, muscle-containing portion by a strong ridge running parallel to the anterior margin; ischium and merus, also, are produced posteriorly, but in these it is not a plate-like expansion but an actual widening of the joint for the accommodation of muscles. The ischium in the peraeopoda generally is rather shorter than usual. In the three limbs of the hinder series, the dactyl, too, is extremely well-developed (again as in *wianamattensis*).

The brood-pouch in this species is very large and may contain as many as 109 embryos—the largest number recorded for any Phreatoicid.

The male appendage is unusually long, slender, tapering, and recurved, with its mesial border deeply grooved.



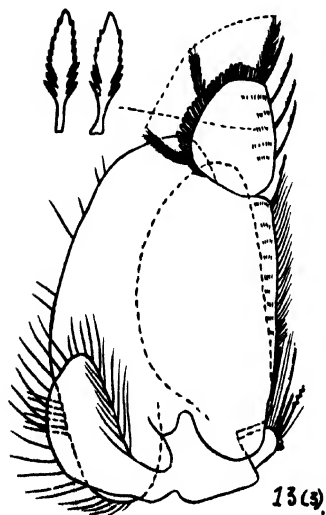
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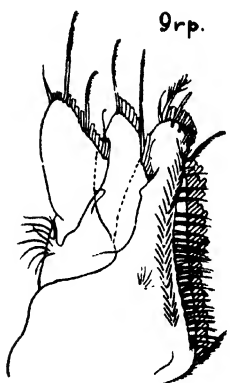
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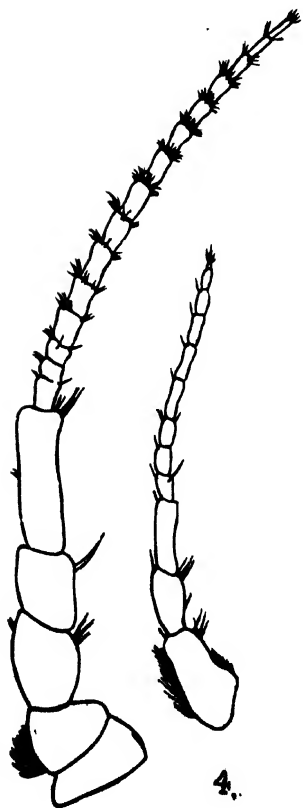
13(2)



13(3)



9rp.



4.

The *pleopods* show a far greater resemblance to those of *Amphisopus* than to those of *P. australis*, to which Chilton compared them (1922, p. 30). Sheppard's statement that, in this species, there is a replacement of plumose setae on the exopodite by simple setae is quite incorrect. There are, however, numerous other and more striking differences.

In the first pleopod (fig. 23, 13(1)) the sympodite is shorter relatively than in *P. palustris*, having a wide-based and convex mesial plate well developed, carrying long, stiff setae and three or four coupling hooks on its free edge; exopodite and endopodite are sub-equal, the former, in the female, fringed from the sub-apical part of its mesial border to the proximal end of its lateral border with sparsely feathered setae, about fifty of these being counted; fewer (thirty-nine) were found in a male of comparable size, these setae being absent (in this sex) proximally, since, in the male, the proximal fourth of this border is thickened and spinulose, a condition rather like that of *Amphisopus* species and one that is found also in some other Isopods (e.g., *Asellus*). Generally, on the hinder face of the exopodite, there is a scattered sprinkling of sub-marginal setules.

The second pleopod (fig. 23, 13(2)) is larger; in the male, the endopodite is narrowed and reaches to the middle of the distal lobe of the exopodite, the penial stylet being stout basally, tapering sharply and curving laterally to its apex, which is devoid of setae, its mesial surface is deeply grooved, its inrolled edges setose. The exopodite is well fringed; distally with fully-plumed setae only, the inner border bears a dense fringe of stiff pectinate setae mixed with simple setae; sub-marginally upon the anterior face along the mesial border are short ranks of four or five stout pectinate spinules. The lateral proximal lobe of the exopodite is well developed; from the sympodite the mesial coupling lobe projects, rounded and distally directed, bearing numerous long setae and a few (two or three) short coupling hooks which spring from the anterior face and are, therefore, not seen in profile; on its outer border, a flat flange is evident and is divided into proximal and distal areas.

The third, fourth, and fifth pleopods are generally alike and differ from the second in the greater width of the lamellae, and in bearing an epipodite, this latter arising from a narrow base and being, in shape, a long oval; it is fringed with long, stiff setae, of which some are pectinate. On the sympodite, entangling setae are more numerous and are pectinate, while coupling hooks are fewer, generally two on the third and fourth and one only on the fifth, this last being sometimes wanting. In general, the setae are more closely set and more numerous upon the distal lobe of the exopodite than in other species, there being as many as fifty,<sup>(1)</sup> but of these some (twenty or more) upon the mesial border of the distal lobe are pectinate with short pectinations on two edges of the seta.

In the female, the pleopods appear less setose and in the case of the second the endopodite is relatively considerably longer.

*Tailpiece* and *uropods*. The paired lobes into which the terminal telsonic region is produced are separated by a narrow median incisure, the lobes being strongly convex, their apices set with setae. Beneath, the telsonic pleura are well developed and broadly convex, their edges set with a practically continuous fringe of stout spiniform setae and spinules, standing out from these being the three paired spines so conspicuous in *Amphisopus*, *Paramphisopus*, and *Synamphisopus*. The anterior margin of the tailpiece descends steeply bearing one or two

(<sup>1</sup>) As against twenty to thirty usually found in other species (cf. *Synamphisopus* and *Phreatoicops*).

longish setae, and then passes into the inferior margin which is armed by one or two spiniform setae and two more posteriorly placed spines. Inferior and posterior margins are separated by the broad insertion of the uropod, somewhat dorsal to which appears a well-defined ridge or suture set posteriorly with a few stout and freely movable spines; it is continued forwardly for some distance towards the anterior border of the tailpiece, being set with a fringe of fine spines and spinules.

The *uropod* (fig. 22, 38), with stout peduncle, broadly concave above, its inner edge set high with a nearly continuous fringe of spines and spiniform setae, is raised distally and bears there two or three much larger spines; the outer edge at a lower level has rather fewer and more widely-spaced spines. The ventral border bears four long and slender spiniform setae not represented by Chilton (l.c., fig. 4), being overlooked probably because they may be folded against the ventral border; inner ramus slender, as long as peduncle, with about five (paired) spines and one longer, flanked by two shorter, on the truncated extremity. The outer ramus is but two-thirds the length of the inner, has three lateral (unpaired) and two longer terminal spines; all of these on both rami being movable. Beneath its insertion springs the usual stout spine which is here without teeth and is guarded on either side by a long and slender spiniform seta.

*Colour.* In most preserved material, these Isopoda appear a uniform slate colour; in some, however, the head shows patches free from pigment—very strongly reminiscent of the yellow areas on the head of *Phreatoicopsis* and *Phreatoicoidea*. In some examples this patch is faintly brown and the middle line of body shows a band of chestnut brown. Two specimens sent by Mr. Sheard arrived still living—one showed the patchy coloration described above, the other (perhaps recently moulted) was uniformly pale brown in colour. Pigmented patches are well developed on exposed surface of maxilliped (less on the epipodite), maxillae, and mandible. The labium, too, though practically concealed, is heavily pigmented, as are the under surfaces of the pleura in the peraeon and parts of the pleopods. Occasionally, small specimens appear pale grey with widely separated dentritic black chromatophores.

These creatures are so unlike other Phreatoicids that even Chilton, in a note probably written when he first received them from Professor Wood Jones, referred to them as 'some Amphipods' (1924, p. 9). Actually (apart from the great expansion of the bases and other joints of the peraeopods) they, more nearly than any other members of this sub-order, bear a resemblance to terrestrial Isopods.

#### Sub-family IV. PHREATOICOPSINAE

Body sub-cylindrical. Head moderately long, with or without cervical groove; eyes large or small with many ocelli. Antennule long, filiform; antenna short. Peraeon segments not differing greatly in length; telson little or not at all produced; pleopods with lamellae lanceolate, sub-equal, without coupling hooks on sympodite; epipodites persist on three or four pairs; penial stylet only slightly curved and either armed or unarmed. Uropods with or without freely movable terminal spine.

This is a somewhat heterogeneous cluster of genera, all monotypic. The body tends to be vermiform with a length round about eight times as great as the maximum width. The fossil *Protamphisopus wianamattensis* and the Great Lake species *Uramphisopus pearsoni* may have a rather more robust habit. All but *Eophreatoicus* have a very marked development of the huge disto-mesial process

upon the uropod which gives to these appendages a tri-radiate appearance like that of some Cymothoidea. In all, the loss of coupling hooks upon the pleopods serves to separate them from the preceding groups, but *Synamphisopus* and *Eophreaticoicus* still retain the two-jointed uropodal rami; the latter, too, retains the large prominent eye which has undergone reduction in all of the other genera. In *Eophreaticoicus* and *Uramphisopus* there is retained something of a produced telsonic apex, in the latter genus this being closely like that of the Great Lake species *brevicaudatus*, while *Eophreaticoicus* is unique in this sub-order in retaining epipodites on four of the five pleopods.

The distribution is interesting: *Eophreaticoicus*, an isolated species from Northern Tropical Australia; *Phreaticoicopsis* from the Grampians, and the Otways *Synamphisopus*, also, from the Grampians. Both of these areas are of Jurassic age and may have been colonized by Phreaticoids in Cretaceous or earlier times. *Uramphisopus* apparently lives in the muddy floor of the Great Lake, Tasmania, an even older area geologically. It has been taken only on three occasions, in every case from the stomach of a trout, and the female is unknown. The fossil *wianamattensis* is of upper Triassic age and in all probability has a kinship with *Amphisopus*. It is with some hesitation included in this sub-family

### **Synamphisopus, gen. n.**

Body scale-clad, slender, sub-cylindrical, its surface practically free from setae. Eyes relatively small, pyriform. Head long with well-developed sub-ocular incisure, without cervical groove, completely united with first peraeon segment; peraeon rather wider than deep, first segment relatively long and very widely expanded at its ventral edge; pleon a little shorter than peraeon, the depth greater than the width. Telson with median dorsal and paired lateral ridges; without terminal projection but hinder border set with stout spines, bounding a large distinctly flattened posterior surface.

Antennule short, scarcely filiform; antenna long; maxillula, inner endite with five setospines not wholly terminal in position, outer endite with an unusually large number of spine-teeth. Maxilla with broad proximal endite, inner distal endite much shorter and narrower than outer. Maxilliped with both coxa and carpus long, and basis relatively short. Coxae of all peraeopods firmly united with their related segments; gnathopod stout, unlike in male and female, dactyl strong and very heavily setose; fourth peraeopod scarcely prehensile, dactyl small; bases of hinder peraeopods moderately expanded; ischia long. In the female, vestiges of oostegite on fifth peraeon segment. Pleopods relatively long as compared with pleura of related segments; anterior face of exopodites setose; coupling hooks wanting; uropods with short peduncle, inner distal angle greatly produced; rami bluntly truncated, armed with strong movable terminal spine, stout toothed spine beneath insertion of rami.

Genotype. *Synamphisopus ambiguus* (Sheard).

This new genus is proposed for a single species which, while presenting a number of primitive characters, seems to occupy a position almost exactly intermediate between *Phreaticoicopsis* and *Amphisopus*. It was originally assigned by Sheard (1936) to *Amphisopus*, but it differs from the species of that genus in a number of important characters, in many of which it comes nearer to *Phreaticoicopsis*. From that, too, it is barred by the possession of equally distinctive features. The length of the head, the reduction of the eyes, the condition of the maxilliped, the short peduncle of the uropod and especially the absence of coupling hooks on the

pleopods and the character of the typhlosole are all features in which it is akin to *Phreatoicopsis* and markedly different from *Amphisopus*. On the other hand, there are to be noted: the ventral expansion of first peraeon segment, the condition of the tailpiece, gnathopods unlike in the two sexes, a slight development of prehensility on the fourth peraeopod of the male, the expanded bases of the hinder peraeopoda and, particularly, the truncated rami of the uropods with their terminal movable spine, and the *toothed* condition of the spine below the insertion of the rami. All of these are characters in which this genus differs from *Phreatoicopsis* and approaches agreement with *Amphisopus*.

In the shape and armature of the telsonic extremity and the disposition of the anal aperture, as well as in the character of the fourth peraeopod of the male, there is a condition intermediate between those that characterize the two genera. The condition of the maxilla and the maxillula and the development of a flattened hinder surface to the telsonic region constitute differences from both *Amphisopus* and *Phreatoicopsis*; and finally in the extraordinary setosity of the dactyl of the gnathopod there is a development recorded for no other Phreatoicid, although, curiously enough, a similar condition is found in different genera of blind or purblind Australian Gammarids.

#### *Synamphisopus ambiguus* (Sheard)

(Fig. 24)

Sheard, 1936, p. 469, figs. 1-18 (*Amphisopus ambiguus*).

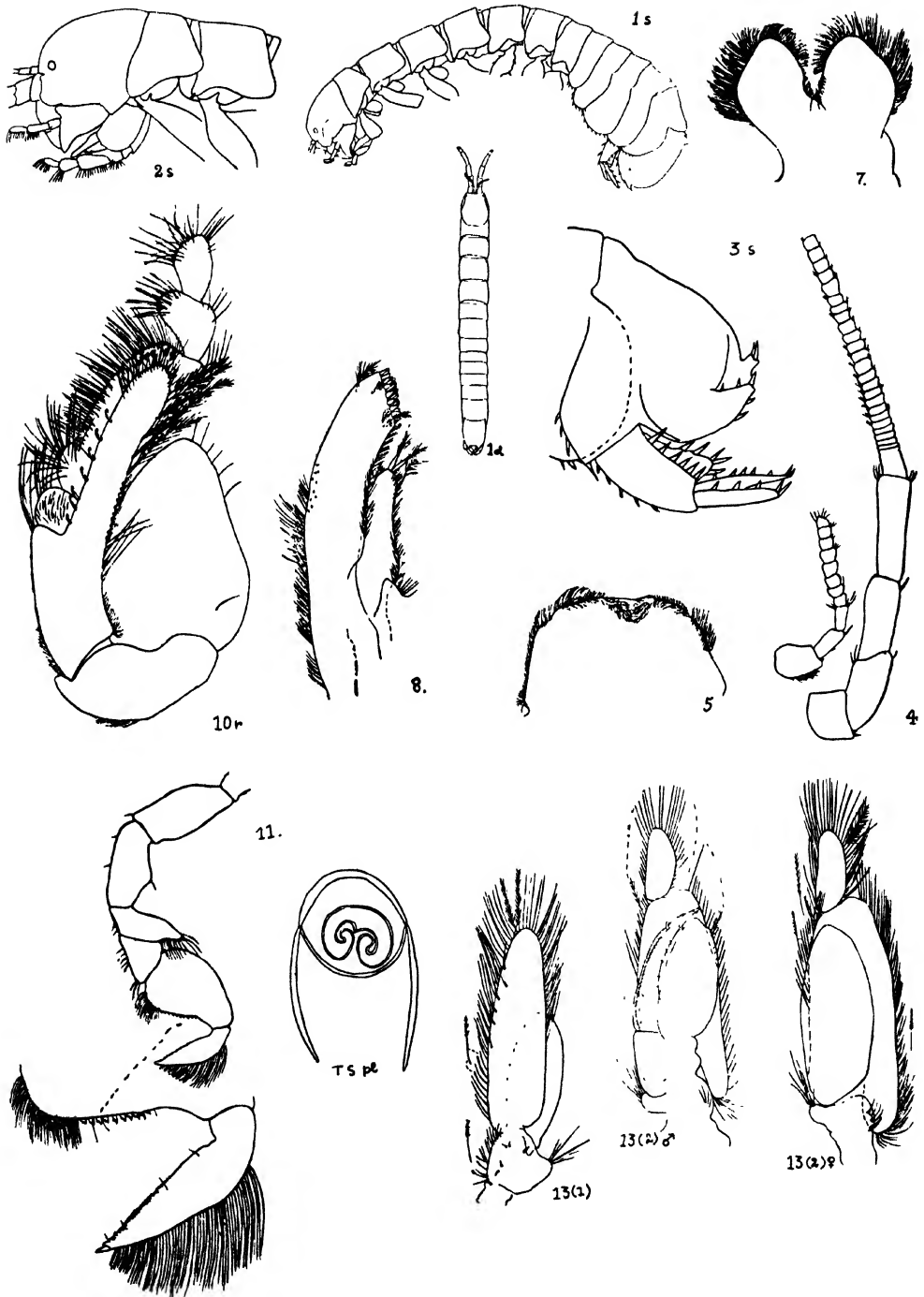
To Sheard's description of this fine species, a number of details may be added.

The *body* (fig. 24, 1s) is more nearly linear than that of any other species, excepting only those blind forms which have become entirely modified for life in subterranean waters. It is vermiform, the body being almost parallel-sided, width being practically uniform and the length approximately eight times as great as the width.<sup>(1)</sup> The surface appears smooth and is nearly free from setae, but is uniformly scaled, this condition extending to all the appendages. It is very noticeable in the last five joints of the gnathopod. In the female, the pleon as a whole is slightly narrower than the peraeon.

In dorsal view the *head* is seen to be a little longer than wide, the width being equal to its greatest depth. The length is sub-equal to, or slightly greater than, that of the first and second peraeon segments combined. The anterior border is distinctly emarginate, the front rising quite steeply from a well-developed, slit-like, sub-ocular incisure. On its anterior surface is a stout median rostral ridge. The eyes seem small, although there are about twenty-five to twenty-eight ocelli. The sub-ocular segment is not very definite but the genal groove is deep, the cheeks swelling out below it, as in *P. terricola*. The ventro-lateral border is sinuous; it is deeply concave below in the region of the anterior mandibular fulcral process, which is particularly large; this is followed by the slightly convex line of the mandibular articulation. Behind that, it dips steeply into the post-mandibular region, then crosses that area in a ridge, cutting off a small irregular ventro-lateral area below and extending behind the mandible into a small 'posterior process'. There is no trace of a cervical groove and the head is fused behind with the first peraeon segment.

*Peraeon*. In length, the third, fourth, and fifth segments are sub-equal, the second and sixth slightly shorter, while the first and seventh are barely half the

<sup>(1)</sup> In these proportions agreeing nearly with *Eophreatoicus*, (male).

FIG. 24.—*Synamphisopus ambiguus* (Sheard).



length of the longer segments. The first segment is greatly widened ventrally to embrace slightly the postero-ventral corner of the head, its depth being considerably greater than its length. In this widened first peraeon segment, completely fused with the head and backwardly overlapping the second segment, there is an approach to the development of a carapace. The second segment appears about as deep as long, but the next succeeding segments are longer than deep; the sixth and seventh are deeper, the seventh having a depth twice its length. The pleon has a length of two-thirds only of the peraeon, being a little longer in the male; the first three segments are sub-equal, the fourth slightly longer, fifth twice as long as third and a little shorter than the tailpiece.

The pleura are fringed ventrally by slender spines, a slight notch marking the junction with the related segment in the second to fifth. In the tailpiece, the suture of the sixth segment to telson is seen at the ventral end, there being only a short ridge, which is wholly unarmed.

The telson (fig. 24, 3s), in profile, resembles that of *Amphisopus*, there being a distinct median ridge which is not produced into a spine. It is flanked on either side by a lateral ridge which ends behind in a stout movable spine. Below, the telsonic pleuron bears a second spine, its convex border there curving anteriorly to the insertion of the uropod. The hinder surface of the telson is flattened as far down as the level of the lower pair of spines, beneath which level the ventral end of the body slopes away anteriorly, the anal opening being postero-ventral.

Anterior to the insertion of the uropods, the pleuron of the sixth pleon segment is armed with a very stout spine terminally, preceded by a series of three simple spines decreasing in size and length forwardly.

The *antennules* (fig. 24, 4) are short and stout, but *Amphisopine* in character. They do not reach to the end of fourth joint of peduncle of the antenna, although there are as many as nine or ten (eight in female) joints in the flagellum, the last minute. The first joint of the peduncle is broadened laterally where it rests upon the *antenna*. This is long (two-thirds the length of the animal), the peduncle robust, especially in the male; first and second joints wide, the third with length as great as the width of preceding joints, fourth rather long, four-fifths of the fifth joint; flagellum practically twice length of peduncle, with about fifty joints. In the female, the basal joints are less wide and the proportions slightly different; the number of flagellar joints seems to vary from thirty-one to thirty-six.

*Upper lip* (fig. 24, 5). Epistome with strong median ridge; labrum relatively short and wide, its ventral border only moderately convex—almost straight mesially and slightly excavated dorso-laterally where fulcral processes of mandibles abut against it.

*Mandibles*. These have been figured very fully (fig. 3). The left mandible, in external view, shows a large basal portion produced into distinct fulcral and acetabular prominences, the palp with first joint rather long relatively. Seen from the mesial aspect, the long, straight hinge-line forms the outer and upper border of a large aperture for the adductor muscle with its wide fan-like apodeme. The short, broad molar springs from immediately beneath this aperture and overhangs the oval spine row and doubly dentate edge. In the antero-mesial view, the spine row is found to rise on a short pedicel, which is armed by spinules and setae. The right mandible seems smaller; the inner dentate edge (*lacinia mobilis*) is bifid; the spine row differs somewhat; the molar is large and obliquely truncated, the first joint of palp relatively longer.

*Lower lip* (fig. 24, 7) stout, inner lobes not recognizable, outer lobes sub-quadrangular, mesial edge fringed distally with setae in tufts almost concealing some eight to ten setospines.

*Maxillula* (fig. 24, 8). Inner endite unusually short and narrow, its apical edge oblique and carrying five slender setospines, with which are short fine setae, but the characteristic slender spines usually accompanying these are wholly wanting. Outer endite broad and considerably larger than inner, its free surface narrow and very oblique with about thirty spine-teeth arranged in double and treble rows. On the posterior face near to the mesial edge are two short, feebly plumose, setae; more centrally, two others and sub-terminally another and much stouter plumose seta which arises barely within the lateral margin. Only exceptionally (*M. tasmaniae*) is this rank of plumose setae found so well developed in other species.

*Maxilla*. This appendage is remarkable, in this group, in the great reduction of the inner member of the distal endites, although there is seen a tendency in this direction in *P. terricola*. In other respects, also, the maxilla agrees more nearly with that of the latter species. In its shape the inner endite recalls the condition of *typicus* or *capensis* and differs markedly from that of either *Amphisopus* or *Phreatoicopsis*. On its inner margin very strongly developed is an anterior row of slender pectinate setae (fig. 5C, 5D, *a.s.*); behind this lies the mesial comb-like row of filtratory setae (fil.) separated by the width of the mesial surface. This ends abruptly and, at the point where this row ends, the distal part of the lobe is bent sharply mesially, producing a distinct notch. The row of setae is flanked posteriorly by the more widely-spaced pectinate setae (pct.) which form a supporting row, these setae projecting nearly at right angles, for which reason they may be made out, in permanently mounted preparations, only when examined in posterior view. Closely behind this lies the posterior row (p.r.) of fine setae. The inner of the two endites of the third segment is not only short, but is narrow and is so disposed that studied in its natural position it is to be seen only from behind. Owing to the mounting of this appendage so obliquely to the long axis, combined with the antero-posterior disposition of the joint itself, this endite lies practically mesially to and behind the outer endite. The slender pectinate setae at its apex are continued down its mesial face by stouter, more widely separated setae. Lateral to it, the large outer endite presents an inner concave face overlapping the lateral border of the proximal endite and practically hiding the anterior face of the inner distal endite. The mesial face of this outer endite, too, is armed with numerous setae, many projecting to form a stiff postero-mesial fringe, while apically a few of the terminal spine setae are very much stouter, although not comparable to the great spines found in this position in *terricola*. Well developed as this joint is, it scarcely passes the apex of the proximal endite which seems unusually large, and the whole of the distal part is thickly furred posteriorly with long, fine setae, so that the apical cluster becomes brush-like rather than a fringe.

The *maxilliped* (fig. 24, 10) shows a greater likeness to that of *Phreatoicopsis terricola* than to that of any other species. The coxa is stout and relatively long and bears an irregularly ovate epipodite near the outer distal angle, on which are a number of short spinules interspersed with longer setae. The basis is about half as long again as the coxa but its endite is unusually stout and long, extending well beyond the middle of the carpus; the latero-distal angle of the basis bears a cluster of long, plumose setae which in other species is usually represented by one or, at most, two. The endite has the whole length of its antero-mesial edge armed with an unbroken rank of stout plumose setae (thirty or so) which pass apically (i.e., anteriorly) into a terminal tuft of mingled plumose, pectinate, and simple setae. From the apex, this cluster passes into a ventro-mesial fringe of pectinate setae, the seven hinder members of this series becoming

sub-marginal and transformed into coupling hooks. The ventral (mesial) border of the distal four joints of the palp are set with a continuous fringe of long setae, that on the last two joints being exceptionally well developed. The propod is markedly produced mesio-distally (a condition seen equally well developed only in *Phreatoicopsis*, and recalling the endites of ischium and merus in *Mysis*). In addition to these bordering fringes, the distal end of each joint bears a terminal row of setae standing out stiffly perpendicularly from the segments and the carpus appears to be widened to a mesial face, heavily furred with setae, the whole appendage having an extraordinary setose character. This condition is also seen in *P. terricola*, but in that species there are, in addition, setae standing out haphazard from all the ventral and lateral surfaces—these being wanting in *ambiguus*.

In the females examined, none show other than the incipient stage of the brood lamellae and the maxilliped has only a short outstanding crescentic lobe (without setae) springing from the mesial angle of the base of the coxa.

The gnathopod differs in the two sexes. In the male (fig. 24, 11) the appendage has a condition intermediate between that figured by Spencer and Hall (1896) for *P. terricola* and that shown by Raff (1912) for less mature specimens. The ischium is but little shorter than the basis and considerably stouter; about its middle, on its anterior aspect, is a stout spine. The merus is greatly produced anteriorly and the apex of the process may have one or two spines, the process being downwardly turned, as in Raff's figure of *terricola* (1912, pl. 5, fig. 5). The propod is more nearly sub-triangular than in the case in *P. terricola* and with the palm rather more oblique and less convex. There is a rounded boss at the distal end of the palm in place of the tooth of Spencer and Hall's figure (1896, pl. 3) and the dactyl also bears a rounded elevation which fits upon a corresponding distal concavity of the palm. The proximal (slightly convex) part of the palm has a number of characteristic short pectinate spines. Another large male shows the palm more sinuous and thickly setose. In both specimens, the dactyl is much more robust and relatively shorter than in *P. terricola* and is unlike that of any other Phreatoicid in that its outer (anterior) border bears a dense fur of long setae comparable only to that found in several of the blind Australian Gammarids. Such a condition is known for no other Phreatoicid. That this is not noted in Sheard's account of the male is doubtless to be explained by the fact that dried material only was available and this had probably suffered damage to the more delicate structures. It was recorded for the female, where the condition of the several joints of the gnathopod is not unlike that figured by Sheard for the regenerated appendage in the male. It is, however, still more heavily setose than the male and the dactyl in both male and female has its inner margin finely serrated or denticulate. The ischium in the female gnathopod is more slender and the merus not so strongly produced.

In this and all the succeeding peraeopods, the coxa, though clearly defined, is apparently firmly united with its related segment.

Unlike *terricola*, however, the second, third, and fourth peraeopods show progressively the ischium decreasing in length (relatively to the basis), the merus more downwardly produced, the carpus shortening and widening. In the fourth peraeopod of the male, there is a distinct suggestion that the distal three joints may have some prehensility as in *Amphisopus*, etc.

The hinder group of peraeopods (fifth to seventh) are all longer, the basis is widely expanded, its anterior border notched and armed with spinules, its posterior border bearing short, stout spines; the ischium relatively longer. In all the peraeopods there is a secondary unguis present.

From the coxae of the seventh pereopods arise the unusually long, strongly curved and slender penes which meet in the middle line, at the level of the distal ends of the sympodites of the first pleopods.

In the non-ovigerous female, brood lamellae are found on the first to fourth pereopods, those on the gnathopod having the characteristically bilobed condition. The oviduct appears to open at the inner end of a raised ridge that may perhaps represent the fifth oostegite fused with its related sternite.

The *pleopods* are long, relatively to the associated pleura, so that much of the appendage is exposed. The first pleopod (fig. 24, 13(1)) has an exopodite of lanceolate shape, bluntly rounded apically, being in this quite distinct from *P. terricola*, which it resembles, however, in the reduced size of the endopodite, which is relatively smaller even than that of *Amphisopus lintoni*. The pleopod, however, differs from that of *Amphisopus* in the complete absence of coupling hooks and the two pleopods of opposite sides are held only by entangling setae springing from a well-marked mesial process of the sympodite. The lateral margin of the sympodite extends as a flattened plate (?reduced epipodite) with abundant fringing setae. The endopodite is without setae; the exopodite is fringed with setae along the distal half of its mesial border and practically the whole of the lateral border, some sixty or more of these being plumose. There are, in addition, some sub-marginal setae both mesially and laterally and near the apex there are numerous setae springing from the anterior face of the lamella (cf. *brevicaudatus* and *lintoni*).

In the second pleopod of the female (fig. 24, 13(2) ♀) the endopodite is a long ovate lobe, extending nearly to the end of the proximal exopodite lobe; the distal lobe of the exopodite is a long, narrow oval bearing about forty plumose setae. The proximo-lateral lobe of the exopodite is present but does not extend so nearly to the sternite as in *Phreatoicopsis*, while the coupling lobe of the sympodite bears only two or three entangling setae.

In the male, the stout, curved penial stylet (fig. 24, 13(2) ♂) is marked off distally from the respiratory part of the endopodite. It is distinctly of the *Amphisopine* type and without setae or spines. The basal (muscular) part of the endopodite is strongly developed.

In the hinder pleopods, the principal difference lies in the occurrence of free epipodites.

*Uropods*. These show a condition that is largely intermediate between that found in *Amphisopus* and *Phreatoicopsis*. The peduncle is short but, as compared with the tailpiece, much longer than in *P. terricola*. Its inner upper border is high with a number of spines and setae and produced into that strong distal process found well developed in so many burrowing forms, and, as usual, surmounted by two powerful spines. The outer upper border is much lower and slopes downwardly to the end of the peduncle, being armed with four or five longish spines. Its ventral edge bears five spines laterally rather than ventrally and these can be folded down and thus are readily overlooked. The rami, too, are longer relatively than in *Phreatoicopsis*; they are styliform and flattened dorsally and end bluntly, the upper surface of both bearing three or four movable spines, one large and one rather smaller terminating each ramus; as is so generally the case in *Phreatoicids* the inner ramus is distinctly the longer. Beneath the insertion of the rami is a stout spine, pectinate rather than toothed, flanked by a smaller but simpler spine.

A typhlosole (fig. 24, T.S.pl.) of the type recorder hitherto only in *Phreatoicopsis* is well developed in this species.

*Occurrence*. The Grampians, Victoria, in a creek below Fish Falls, under stones.

*Colour.* In spirit material pale yellowish-grey with darker marbling.

*Size.* Male, about 25 mm. in length. Largest female (immature), 22 mm.

Some six or seven examples of this species were collected by the late Dr. R. J. Tillyard in the summer of 1933-34, and were kindly sent to the writer for determination. They were examined and described as representing not only a new species but as requiring a new genus for their accommodation, the species being named for its discoverer; the description was, however, not published at that time, being withheld in order that it might be incorporated in the present work which even then had already largely taken shape. But in the following year specimens collected by R. V. Southcott were sent to the South Australian Museum. These, which unfortunately were preserved dry and were not very suitable for detailed investigation, supplied the material for Sheard's description. Later these, too, were sent for examination to supplement the incomplete material available, but neither collection contained mature (ovigerous) females. In the summer of 1939, an attempt was made to fill this gap, but unfortunately the season was excessively hot and dry and the collecting trip yielded nothing.

### **Eophreatoicus Nicholls**

Nicholls, 1926, p. 190 (*Eophreatoicus*).

*Body* sub-cylindrical, fusiform, scale-clad, wrinkled transversely; *head* short, with slight sub-ocular incisure and strongly-developed cervical groove. Eyes large, prominent, with many ocelli; first peraeon segment of moderate length, apparently fused with head, pleon comparatively long with deep pleura, first four segments sub-equal, fifth as long as the tailpiece, terminal projection very slightly developed, not upturned.

Antennule with many-jointed flagellum, antenna moderately short with peduncle robust; mandibles short, stout, palp with joints short and broadened; gnathopod, alike in both sexes, strong, hand primitive, the straight palm occupying the entire posterior margin of propod; fourth peraeopod in the male probably with terminal *three* joints for grasping; all peraeopods with merus expanded, basis and ischium greatly expanded on fifth to seventh; pleopods with exopodite and endopodite sub-equal, without coupling hooks; first pleopod with rami long and sub-lanceolate; epipodites on second to fifth pleopods; penial stylet cylindrical, curved, armed terminally; uropod expanded; inner ramus lamellar, outer more nearly styliform, both blunt-ended with movable terminal spines; spine beneath insertion of rami simple.

Genotype. *Eophreatoicus kershawi* Nicholls.

### **Eophreatoicus kershawi Nicholls**

(Fig. 25)

Nicholls, 1926, p. 190, figs 17-39 (*E. kershawi*).

*Body* robust, sub-cylindrical, having through the peraeon and part of pleon a nearly uniform width which is rather greater than the depth (as 5 : 4). The head is slightly narrower and, behind, the pleon tapers gently from the third segment, the body being sub-fusiform, its length in the male being nearly eight times its greatest width, as in *Synamphisopus*. In the female, the peraeon is markedly

broadened, so that the greatest width is a little more than one-fifth of the total length. The surface is everywhere scale-covered and with fine setae sparsely scattered; in the peraeon and part of the pleon there are low transverse wrinklings.

The head is scarcely longer than the third peraeon segment, considerably shorter than the combined length of first and second segments. In profile it appears almost as a quadrant of a circle, rising steeply in front. The eyes are exceptionally large, sub-circular and very prominent, having about one hundred ocelli. A sub-ocular incisure is barely indicated by a shallow groove.<sup>(1)</sup> The anterior border of the head is distinctly emarginate, above a narrow vertical rostral ridge; the interocular space wide, although little more than once and a half the greatest diameter of the eye. Its ventro-lateral border, nearly horizontal anteriorly, bends gently downwards into the post-mandibular region. Arising from the posterior border, a deep cervical groove marks off incompletely the maxilliped segment behind which the first peraeon segment is forwardly produced to embrace the head with which it is firmly united.

The peraeon appears compressed, but is actually slightly wider than deep (5 : 4) in the male; in the female, the greatest width may be almost twice the depth. The second, third, and fourth peraeon segments are sub-equal; fifth, sixth, and seventh decreasing progressively in length, the seventh sub-equal to the first. This first segment is turned forwardly at its lower end to overlap slightly the hinder lower corner of the head, but the segment is not noticeably widened below, thus differing markedly from *Amphisopus*, *Synamphisopus*, and *Phreatomerus*, but resembling *Phreatoicopsis* and *Mesamphisopus*. The coxal plates are small, the hinder three not entirely marked off from their related segments.

The pleon is relatively long, almost equalling the peraeon, the first segment sub-equal to the first peraeon segment, second, third, and fourth progressively longer, fifth as long as combined length of third and fourth and sub-equal to tailpiece.

The pleura are deep, the fourth segment having a depth three times its length; that of the fifth segment is shallower and meets its segment at a sharp angle posteriorly. In a mounted preparation of all these pleura, there is to be seen a dark line (probably a thickening of the chitin) at the level where pleuron and tergum meet (fig. 25, *pl. 3*, *pl. 4*). In the second, however, there is a distinct fold in this region suggesting that the pleuron is an epimeron (prae-coxa) which has become sutured to its segment, this condition being closely comparable to that existing in the peraeon of those forms in which the coxae are firmly fused with the related segments.<sup>(2)</sup> The ventral margins of these pleura are armed with a few widely spaced spinules, which occur only around the curved lower part and are not developed upon the posterior borders.

In all these segments, there are slightly developed transverse wrinklings, scarcely to be called ridges, and if a portion of the lateral surface be examined under a high magnification, the uniformly scaled condition is seen to bear broken transverse lines of sparse and minute spinules in vertical rows, each row apparently marking the line of a ridge.

In the tailpiece, the distinction between sixth segment and telson is very slightly indicated; dorsally, perhaps, by a little-developed crest running transversely and forwardly, parallel to the hinder border of the piece, near its posterior

(1) A condition approached by *Phreatoicopsis* and *Synamphisopus*.

(2) It is of interest, in this connection, that in several of the specimens of the fossil *Iranamattensis*, the pleura were apparently readily disconnected from the related terga (Chilton, 1917, figs 3 and 4).

end,<sup>(1)</sup> and ventrally by a short ridge directed antero-dorsally from the insertion of the uropod. Under low magnification, this ridge appears unarmed, but, more highly magnified, is found to represent a continuous line of short, stout spinules. The significance of these spinules is obvious when it is noted that such a line of spinules arms the posterior pleural edge of the telson and that a comparable series is found along the borders of the hinder peraeopods (fig. 25, *p.mv.*). It is very probably indicative of an originally free edge, in this case the hinder margin of the sixth pleon segment. The terminal projection is but a rounded oblong knob, flattened below and armed with four stout spinules and several setae. It is flanked on either side by a stout movable spine capping a strong projection, evidently the postero-dorsal end of the related pleuron; more ventrally, a similar but smaller spine occurs, the profile of this telsonic pleuron being strikingly like that of *A. lintoni*. There is, however, a narrow flattened posterior surface which is not found in that genus, but is better developed in *Mesamphisopus*, *Uramphisopus*, and some of the Phreatoicine forms.

Anterior to the insertion of the uropod, the pleuron of the sixth segment (fig. 25, *pl. 6*) bears a very stout, simple spine posteriorly, flanked mesially by a stout spine, toothed apically and preceded by a series of ten or eleven similarly toothed spines decreasing progressively in size until the uppermost is a slender spinule lying wholly sub-marginally. The anterior margin passes upwards almost vertically, so that the tailpiece is very short below (antero-posterior measurement) and resembles, rather closely, the corresponding region of *Phreatoicopsis*.

*Appendages.* These are described rather fully in the original account (1926), but there remain numerous details which were overlooked or the significance of which was not, at that time, sufficiently appreciated.

The *antennule* reaches to the end of the second joint of flagellum of the antenna. The peduncle, which is a little shorter than the flagellum, is not well defined and may be followed by as many as sixteen joints; the first (sometimes, also, the second) flagellar joint resembling the third joint of peduncle, except for size; the succeeding joints are short and sub-rectangular, many bearing sensory setae which differ from the usual 'olfactory cylinders' of this sub-order; the terminal joint is a small knob. The generally scaled condition gives to the outline of the joints a serrated appearance (fig. 25, 4).

*Antenna*, moderately short, less than one-third of the length of the body with first and second joints of peduncle stout and sub-equal, the third slightly longer, but its length less than the width of the proximal joints, while the fourth is just as long as their width. The fifth joint, more slender, is twice the length of the fourth joint and the whole peduncle is shorter than the flagellum which is sub-equal in length to the first antenna. Twenty joints were counted in a flagellum not quite complete, the serrated appearance of the joints being very noticeable.

The *labrum* (fig. 25, 5) is, as usual, asymmetrical, its lower border convex and heavily setose.

*Mandibles.* The left mandible (fig. 25, 6) has the primary cutting edge of four stout teeth, the lacinia mobilis three, nearly as stout; the spine row with eight or nine pairs of stiff curved pectinate spines; dorsal to the palp, the mandible bears a low conical fulcral process; the elongated molar has about four setae arising from the dorsal edge of its tuberculate surface, a condition seen in many Amphipoda; immediately posterior, there is the huge adductor muscle, the lower border of the muscle exit being practically straight and edged with the spinules so characteristic of this species; the palp has the proximal joint short and stout,

(<sup>1</sup>) Cf. *M. tasmaniae*, *Amphisopus*, and *Synamphisopus*.

carrying four spines sub-terminally, the second joint, more than twice the length of the first, is flattened, a broad sub-oval in shape, about fourteen spines arming its dorsal edge and its end; terminal joint, as short as or even shorter than the first, is also broadened, the distal part of the ventral edge having about fourteen stiff setae, of which the two terminal are very long. A stout spine arises from the mandible just posterior to the attachment of the palp.

The *right mandible*, also, has four teeth on a stout primary cutting edge; the lacinia mobilis is more slender, its teeth appear more numerous and are minutely denticulated; the molar is longer, obliquely set, its apex having five longish setae and two shorter curved pectinate spinelets. The hinder end ('acetabular process') of the mandible is somewhat concave, evidently fitting upon an elevated area in the post-mandibular region. In the palp the second joint has about twenty stout spines on the distal three-fourths of its dorsal border.

The *lower lip* (fig. 25, 7) shows no inner lobe. The rounded apex of the sub-quadrangular outer lobe is fringed with stiff curved setae, many of which appear to spring in tufts from a central axis (setospines) comparable to the penicilla found in mouth parts of terrestrial Isopoda.

The *maxillula* (fig. 25, 8) is comparatively stout; the inner endite is broad, its apex somewhat oblique and bearing eight setospines with two simple spines, lying adjacent to the first and third of the apical series. The outer endite is rather longer and distinctly more stout, has about fourteen spine teeth in two (in places, three) parallel rows; the outermost are simple, the more mesial are denticulate on two sides while one near the mesial edge is a plumose spine unusually long although shorter and less plumed than those on the inner endite. On the same (posterior) face of the endite, sub-terminal in position, are a couple of slender plumose setae.

*Maxilla* (fig. 25, 9). The proximal endite has an almost straight mesial border, being without the distal bend. Its anterior mesial edge bears sub-marginally a dense fringe of fine setae; the posterior edge has the usual continuous comb-like rank of filter setae which runs to the apex and passes into the terminal brush. Behind this is the more open row of pectinate setae springing well in from the margin. These, too, stretch practically the whole length of the endite and curving at the apex form the posterior part of the distal brush, among which are simple, pectinate (or biting) and many plumose setae. Farther still from the margin and parallel to the other series of setae is a dense fringe of fine hair-like setae. The arrangement of setal rows closely parallels that recorded for *Synamphisopus*, in which, however, the mesial surface between anterior and posterior edges is particularly wide. The endites of the third segment extend distally considerably beyond the proximal endite; they bear apically and on the mesial faces of both a large number of long and stiff biting setae, while buried among the apical brushes are two very stout spines on the inner and one on the outer endite—very like those described in *Phreatoicopsis*. It seems probable that these proportions of the endites are primitive, the shortness of the outer endites in *Synamphisopus* being due to reduction.

In the *maxilliped*, the coxa is stout but, as compared with the basis, not particularly long; it is extended laterally supporting the epipodite. This is sub-circular and short, reaching only to the distal end of the main sub-oblong part of the basis. Part of its outer surface is crenate, the indentations bearing each a short spinule. The endite of the basis is a long, slender structure appearing lingulate in mesial view and is fringed along the whole length of its dorsal edge



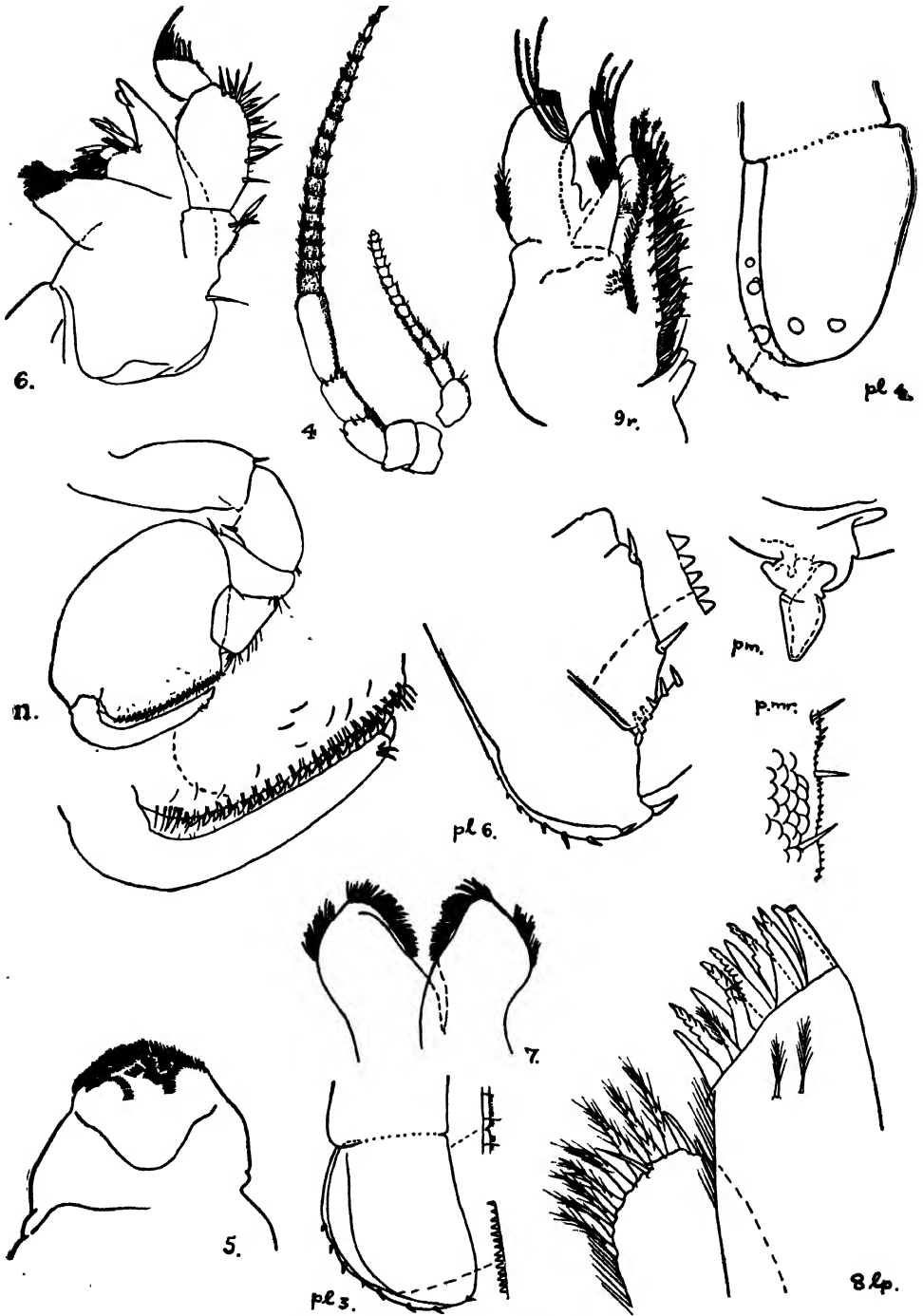


FIG. 25. - *Eophreatoicus kershawi* Nicholls.

with stout plumose setae, replaced at the apex by pectinate setae. It reaches distally mid-way along the carpus and bears on its mesial surface four stout barbed coupling hooks, and is clothed apically with the usual brush of simple, pectinate and plumose setae. The disto-lateral angle of the basis bears a couple of stout plumose spines, as in *Amphisopus*. The propod is flattened, sub-circular, the dactyl sub-oblong; the inner borders of the distal three joints are heavily setose.

The *gnathopod* (fig. 25, 11) is notable for the relative shortness of the ischium; the merus is produced anteriorly into a truncated conical process, armed like that of *Phreatoicopsis* and *Synamphisopus* with one very stout spine; the proximal border of the propod is sinuous, being excavated by the carpus. The propod is very massive, as broad as long and correspondingly thick; the palm, which occupies almost the whole posterior border of the joint, is practically straight and is armed with the characteristic spine-teeth which are particularly well developed proximally, the dactyl is stout, has developed a sharp bend near its insertion and then is straight, lying parallel to the palm.

The succeeding three peraeopods show two features which are without parallel among living Phreatoicids: (1) The antero-proximal angle of the bases of second to fourth peraeopods is produced into a short stout process crowned with a tuft of stiff spine-setae; these are the more conspicuous because the remainder of the surface of the joint is practically unarmed. It seems altogether probable that these elevations represent the last vestiges of the vanished exopodites of these limbs. It will be recalled that in some Anisopoda and Cumacea, exopodites are variably developed or wanting on these appendages. In several species of the more primitive Amphisopine genera, traces of this structure are seen, but in none of these does it attain the development found in this species. (2) The other feature peculiar to this genus is the large degree of *anterior* expansion of certain of the joints (particularly basis,<sup>(1)</sup> ischium, and merus) of these three peraeopods, and the posterior expansion of ischium and merus, as well as of basis in the fifth to seventh peraeopods. This condition is approached elsewhere, among the Phreatoicidae, only in the fossil species *wianamattensis*, and, less evidently, in *Synamphisopus*. The length of the fifth peraeopod is less, rather than greater, than that of second or third; while the sixth and seventh are considerably longer (at least one-third). In all three of these limbs of the hinder group, the ischium and merus bears a powerful spine postero-distally; the more distal joints bear a number of spinules and spines but the basis is almost without setae, its thin membranous expansion being feebly crenate behind, each of the indentations bearing a short setule which may be feebly ciliated. The dactyl is, in all the peraeopods, supported by a small secondary unguis.

The *pleopods*, too, retain several primitive features not occurring in other extant forms. First pleopod has broad sub-oval and sub-equal lamellae springing from a wide and stout sympodite, on the lateral aspect of which there is a widely-expanded membrane (1926, pl. 27, fig. 24), armed with a fringe of setae, which suggests a reduced epipodite fused with the sympodite. Mesially, another widely expanded lobe bears the entangling setae. These are arranged in two tufts, one proximally and the second apically. Laterally, the exopodite is produced into a proximal lobe lying behind the reduced epipodite; its outer border for half its length is fringed with simple setae which are replaced, in the distal half, by plumose setae, continued around the apex for the distal fourth of the mesial border.

(<sup>1</sup>) The basis of first to fourth peraeon appendages has a comparable anterior expansion in *Paramphisopus*.

Here, the plumose setae are discontinued and the mesial border is free from setae of any kind. Laterally and apically, a few simple setae are sprinkled sub-marginally. The endopodite is bare of setae, although a rare crenation of its margin suggests that setae originally fringed this lamella as they still do in *Mesamphisopus*, *Notamphisopus*, and *Hypsimetopus*.

It is in the second pleopod that this species exhibits the most striking peculiarities. In general, it resembles most nearly the second pleopod of *littoralis*, but from this, and, indeed, from all living Phreatoicids, it differs in that it retains a free epipodite. This is large, an elongate reniform in shape, with relatively few simple setae. The coupling lobe is produced mesially and bears a single tuft of numerous entangling setae. On the exopodite, plumose setae are restricted laterally to the distal half of the proximal lobe and the outer border of the small sub-circular distal lobe. Mesially, this distal lobe has simple setae only and these continue on to the proximal lobe, forming a dense fur of fine, stiff setae marginally and sub-marginally for about one-third of the mesial border. Proximally, the exopodite is produced both laterally and mesially, almost completely hiding the anterior face of the sympodite. The endopodite is sub-equal to the proximal lobe of the exopodite and, in the male, bears a long, curved, cylindrical penial stylet (1926, pl. 27, fig. 26). This, too, differs from that of all other known species in the degree of development of its terminal armature of numerous (about thirteen) stiff setae. The fringing setae along its inrolled free edges are also more numerous than in other species, the condition in *Mesamphisopus* perhaps most closely approaching it.

The sternite of this second pleon segment bears mesially, between the pleopods, a curious structure whose function is not obvious (fig. 25, *pm.*). In its appearance, there is something suggestive of a small *petasma* (cf. *Leucifer*). The only preparation examined, in which it appears, is one in which the pair of pleopods were removed together with the intervening sternite. It is not certain, therefore, whether it is of constant occurrence in this genus.

Third to fifth pleopods differ, as in practically all the members of this sub-order, in shape and relative proportions of exopodite and endopodite. The epipodite is large and sub-quadrangular, but in the fifth it is almost sub-triangular. The other lamellae become increasingly shorter and wider, but the endopodite retains its general sub-equality to the proximal lobe of the exopodite, the coupling lobe increases in size.

The *uropods*. These are stout and comparatively short, the length of the peduncle (measured along its ventral border) being only about twice as great as its depth at its attachment. The inner border of the peduncle is raised into a high and thin membranous lamella armed with ten to a dozen spines of various sizes, the two largest being sub-terminal. The outer border is low and bears about four spines which increase in size posteriorly. The inner and larger ramus is a thin lamellar structure, fringed nearly continuously with spines of varying sizes and ends bluntly with one large terminal spine and a second sub-terminal. The outer ramus is more nearly styliform and shorter by one-fourth of its length, bears fewer spines, two being terminal and sub-terminal. Beneath the insertion of the rami is one large and strong simple spine, flanked by another similar but much smaller.

*Occurrence.* This species has been taken once only, by W. M'Lennan (Nov., 1915) at Sandstone Bluff in Arnhem Land, Northern Territory. In a letter received from Mr. Kershaw, it was explained that the 'water hole' was in all

probability in the Sandstone Ranges, near the King River about 90 miles east of Port Essington. M'Lennan's diary, edited by Captain H. L. White and published in 'The Emu' (vol. 16, 1917, p. 138) gives some further details concerning the difficult nature of this region. About a hundred specimens were taken (M'Lennan, 23.11.15), of which about three-fourth were male; no mature females were represented in the collection.

*Size.* Males in length from 12 to 21 mm., width 2.5 mm.; immature females may reach a length of 14 mm. and a width of 3.5 mm.

*Colour.* In spirit, yellowish grey with dendritic spots variably abundant which occasionally unite to form dark bands.

In the sum total of its characters *Eophreatoicus kershawi* probably retains most nearly the primitive *Amphisopine facies*, although in many of its features it may have become specialized.

In all probability the following characters are primitive, (i) the general proportion of the body, its marked scaliness and the retention of transverse ridges; (ii) the well-developed filiform antennule, the relatively short antennae and the prominent, multi-faceted eyes and conspicuous cervical groove; (iii) the condition of the mouth parts; (iv) the simply sub-chelate character of the hand of the gnathopod, involving the whole posterior border of the propod as a palm and the retention of possible exopodite vestiges on the bases of the anterior peraeopods; the expansion of the bases of all the peraeopods, the shortness of the ischium and the expansion of this joint and the merus; (v) in the pleopods the outstanding character is the retention of an epipodite on the second pleopod; the penial stylet long, cylindrical, and strongly armed (the typical *Amphisopine* tapering unarmed stylet probably being a derived condition); (vi) on the tailpiece, the short upturned telsonic surface, and in the uropods the lamellar rami, multi-spined and with freely-movable terminal spine or second joint.

The stout, simple spine beneath the insertion of the uropod rami is, also, probably primitive. It may be supposed to have co-existed with one or more toothed spines, which in most *Amphisopine* forms have disappeared, while the simple spine has persisted. In the *Phreatoicine* forms and in *Amphisopus* and *Synamphisopus* it is the simple spine which has gone.

The condition of the typhlosole was unfortunately not noted.

Of possible specializations several may be instanced:—(i) the shortness of the first peraeon segment, but this may well have been a feature of the ancestral *Peracaridan*, and the length of this segment (e.g., *P. typicus*, *M. capensis*) a secondary acquisition—its extreme elongation (*Phreatoicoides* and *Hypsometopus*) is almost certainly a modification associated with the development of a vermiform body in adaptation to life in water-filled, subterranean crevices. In any case one subterranean species (*H. plumosus*) exhibits a short first segment, probably a case of retention of a primitive condition; (ii) the shortness of the coxa in the maxilliped; (iii) the reduction of the coxa and the fusion of this with the tergum in the three hinder peraeopods; (iv) the absence of coupling hooks from the sympodite of the pleopods.

### **Protamphisopus, gen. n.**

Entire animal appearing compressed; head insufficiently known, peraeon with segments much deeper than long, some with a marked transverse ridge; transition to pleon abrupt, the pleon segments being strongly downwardly produced; first

segment shortest, second to fourth sub-equal in length, fifth about equalling combined length of third and fourth; sixth partly marked off from tailpiece, which is little longer than fifth, telson probably not produced into terminal projection.

Antennule stout, multi-jointed; eyes not known.

Basis well expanded in at least the last five peraeopoda, ischia relatively shorter than in any extant form; gnathopod probably with massive propod; merus strongly downwardly produced in third and fourth peraeopods; third to sixth peraeopods apparently sub-equal, seventh rather longer, dactyl very long in hinder three peraeopoda.

Uropod very short, peduncle short and widening distally, rami short, sub-equal. Genotype. *Protamphisopus wianamattensis* (Chilton).

Such characters as are to be made out in these fossils are for the most part not those on which is based the present division of the Phreatoicids into families. Nevertheless, the general facies is so like that of *Eophreatoicus*, *Phreatoicopsis*, and *Amphisopus*, and so unlike that of the Bassian sub-alpine species that it is extremely probable that it is correctly assigned to the *Amphisopidae*.

In the shortness of the ischia it is more distinctly Amphipod-like than any extant form;<sup>(1)</sup> the unusual degree of production of the peraeon segments might possibly have been attributed to a larger (epimera-like) development of the coxae of the anterior peraeopods were it not the typical Phreatoicid coxae are to be made out in some of the remains (Chilton, 1918, fig. 6, p. 376, and fig. 8, p. 377). The shortness of the uropod and the abruptly-ending tailpiece are in marked agreement with *Phreatoicopsis*. The expansion of the basis, the downward extension of the merus<sup>(2)</sup> on the anterior peraeopods, the proportion of peduncle and rami of uropods, the rugosity of peraeon segments, are all features found in *Eophreatoicus*. The appendage identified by Chilton (1917, p. 378, fig. 10) as the antenna is, also robust and short as is the case in many Amphisopine forms (cf. *Phreatomerus latipes*, 1922, p. 27, fig. 1), but it may equally well have been an antennule which, too, is a relatively stout appendage, and in that case would be relatively long and multi-jointed. The near uniformity in the length of the peraeopods is probably primitive (cf. *Acanthotelson*), but the expansion of the basis was doubtless associated with an active swimming habit and may be assumed to have been derived quite independently of any Amphipod relationship. It is exceeded in the existing *P. latipes* from Central Australia.

A specimen, provided by Dr. Tillyard and apparently one which was not seen by Chilton, reveals the dorsal surface (text fig. 26B). It seems to have had a length not greater, and probably less than, six times its maximum width, which suggests a short sub-depressed animal.<sup>(3)</sup> It is possible, however, that the remains are those of a female, and would then have much the same proportions as those of *E. kershawi*. The more anterior, at least, of the peraeon segments were apparently raised into one or, in some cases, two transverse ridges, a feature still preserved in some extant forms. These are shown, also, in one of Chilton's figures (fig. 8, p. 377), although attention was not directed to them.

(<sup>1</sup>) Chilton (1892) was apparently the first to call attention to the fact that in Amphipods this joint is normally short, whereas in Isopods it is relatively long, and he uses that fact as supporting his view of the distinctness of the Phreatoicids from the Amphipoda. It is, therefore, of considerable interest that in the Triassic form this joint was exceptionally short! It may be noted, too, that this joint is short in the Apeudidae with which group the Phreatoicoidea have many features in common.

(<sup>2</sup>) A produced merus occurs also in *P. latipes*, a detail which Chilton's figures (1922, figs 8 and 9) fail to show.

(<sup>3</sup>) It must be borne in mind, however, that the specimen may have been somewhat crushed and so suggest a width greater than was actually found in life.

In this latter figure are possibly represented the second to seventh peraeon and first pleon segments, rather than last five and first two pleon segments as Chilton considered.

In one appendage, apparently the fourth peraeopod, Chilton figures (l.c., p. 378, fig. 10) a rounded boss on the proximal end of the basis. It is of interest that just such a knob is well developed in this position in *Eophreaticus* and represented perhaps in *A. lintoni* and *Uramphisopus* by a well-developed tuft of spines or setae.

### *Protamphisopus wianamattensis* (Chilton)

(Fig. 26)

Chilton, 1918, p. 365 (*Phreaticus wianamattensis*).

Calman, 1918, p. 277 (*Phreaticus wianamattensis*).

Sheppard, 1927, p. 112 (*Phreaticus wianamattensis*).

Barnard, 1927, p. 161 (*Phreaticus wianamattensis*).

With the characters of the genus.

None of the specimens described by Chilton show a modified fourth preaeopod. While this is possibly due to the fact that all specimens seen were females, it being not unusual to find a great disproportion in the number of the sexes,<sup>(1)</sup> it seems more probable that, at that stage in evolution, this modification had not come into existence. Even among extant forms this peraeopod remains unmodified in *Paramphisopus*, *Phreatomerus*, and *Phreatoicopsis*.

Concerning the gnathopod, it is found that in those species with massive propod, this limb tends to become detached at an early stage of maceration, whereas less bulky peraeopods usually remain attached. Since in none, apparently, of these fossils is this first peraeopod preserved the explanation may well be that the gnathopod had, even at that remote period, already undergone considerable development.

While there is perhaps insufficient warrant for the erection of a new genus for this fossil species, of which so very little is certainly known, it is difficult to find as much justification for its assignment to any extant genus and particularly to *Phreaticus*, proposed, as that genus originally was, to receive an extremely specialized subterranean species.

In its general appearance (fig. 26) it seems to have been a blend of *Eophreaticus kershawi*, *Phreatoicopsis terricola*, and *Phreatomerus latipes*; indeed the external features of Amphisopine forms are as much in evidence in this species as in any living form. The fact of its great antiquity renders it unlikely that it would have already lost the lacinia mobilis from the right mandible preserved by so many species or even the second pair of epipodites still retained in one present-day species (*E. kershawi*), unless we are to assume that this latter is a relic even more ancient. A feature on which Chilton relies to disprove the Amphipodan relationship to Phreatoicids (viz., the relative length of the ischium in the latter) is in this species least evident; indeed, the proportions of ischium and basis are much as in Talitrids. It is rather surprising that Chilton, in his account of this fossil, did not note that fact, since, in stressing its likeness to *australis*, he called attention to the fact that the *habitus* figure (1918, fig. 13a) of the latter species

(<sup>1</sup>) Chilton notes that of *typicus* he had no males, and in *Amphisopus* it has been the writer's experience that females are enormously in the preponderance. On the other hand, of *assimilis*, Chilton records but one female; of *Eophreaticus* about 75% and of *Hyperoedonius* probably 90% are males. and Spencer and Hall record that in the batch of *Phreatoicopsis* sent them there were no females, while in the collection of *U. pearsoni* no females were seen in nearly a hundred specimens.

was not wholly correct in respect to the peraeopods, because the ischium is shown as relatively too short; accordingly he gave enlarged figures of third and seventh peraeopods, in which (as he stated) the proportion of the joints was more correctly displayed and in these, the ischia are seen as approximately two-thirds of the length of the bases, whereas in *wianamattensis*, this joint, where well preserved, rarely appears to exceed one-third of the basis. A relative shortness of this joint is a feature also of *Eophreatoicus*, as is, too, the anterior expansion of the merus, although in the extant genus neither of these features is retained in as pronounced a manner as in *wianamattensis*.

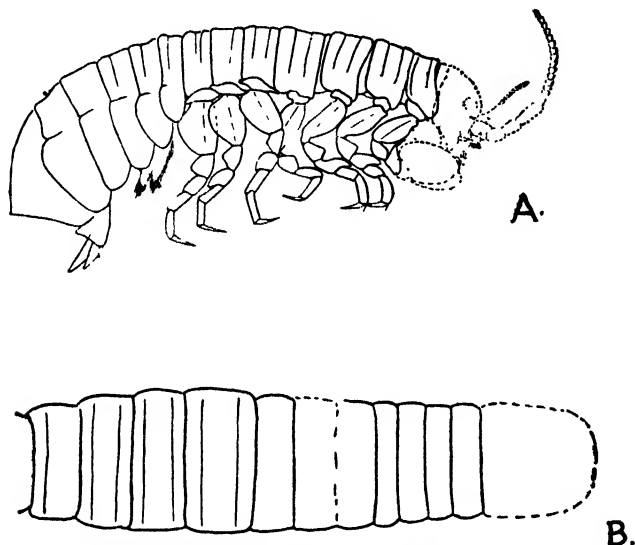


FIG 26.—*Protamphisopus wianamattensis* (Chilton). (A, restoration; B, part of dorsal view.)

There seems to be nothing, in the writer's opinion, in the shape of the telson which in the least recalls the condition found in *tasmaniae*, as Chilton has suggested (1918, p. 375); much more obviously it resembles the truncated end of *P. terricola* or *S. ambiguus*, while the uropods are surprisingly like those of *P. terricola* or *U. pearsoni*.

The proportionate depth of the peraeon segments is more like that of a generalized Amphipod than the condition found in *A. lintoni*, which is, of existing species, probably the most Amphipod-like. Since this earliest of known Phreatoicids had, thus, in Triassic times, a more Amphipod-like form than any of its present-day representatives, and since it was, by that vast interval of time, so much nearer to the common stock, the force of the argument in favour of kinship is the greater, while the supposition that the present-day likeness (which appears much less strong than in the past) is due to convergence, is correspondingly weakened.

### Phreatoicopsis Spencer and Hall

Body scale-clad, stout, linear; peraeon semi-cylindrical (twice as wide as deep) approaching depressed; pleon but slightly compressed, pleura not deeper than related segments; tailpiece almost circular in transverse section; telsonic projection not developed.

Antennule shorter than peduncle of antenna; inner endite of maxilla with complete double row of spines and setae; coxal joints of first four peraeopods in the male, and of the first in the female, fused with the related segment; gnathopod alike in both sexes; fourth peraeopod unmodified in the male; pleopods with lamellae lanceolate, without plumose setae, the first with endopodite shorter than exopodite; sympodite lacking coupling hooks; uropod short extending little behind telson, distal end of inner border produced into strong mesial process, spine below insertion of rami stout, not terminally toothed; rami end in short points and lack freely movable terminal spine.

Typhlosole well developed, spirally inrolled, and extending practically the whole length of digestive tract.

Genotype. *Phreatoicopsis terricola* Spencer and Hall.

### *Phreatoicopsis terricola* Spencer and Hall

(Figs 27, 28)

Spencer and Hall, 1896, p. 12, pls. 3 and 4.

Raff, J. W., 1912, p. 70, pl. 5 (part)

Nicholls, 1924, p. 98; 1926, p. 203.

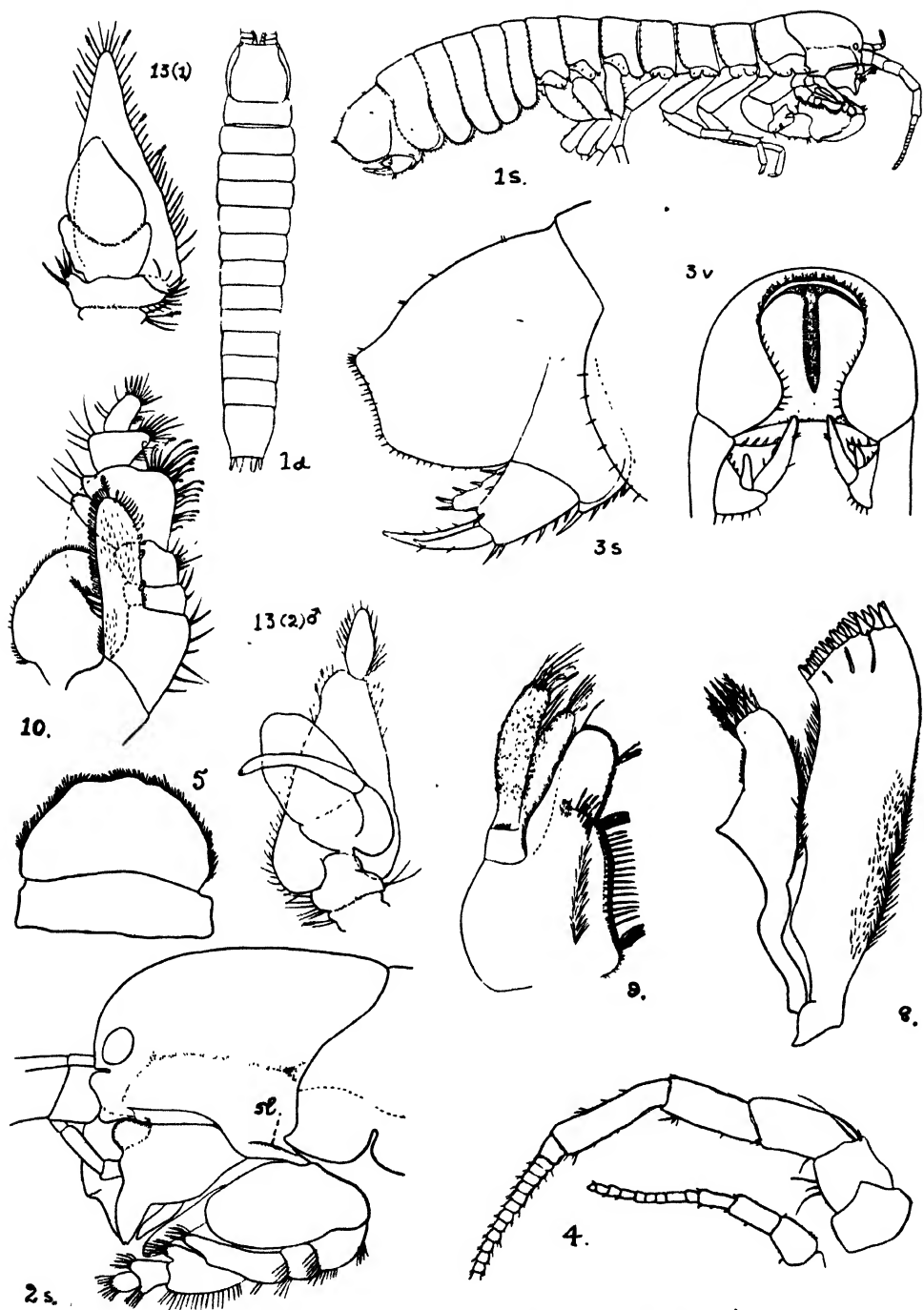
Sheppard, 1927, p. 117.

Barnard, 1927, p. 160.

This, the largest living Phreatoicid, has a stout vermiform body, widening a little in mid-peraeon and thereafter tapering slightly posteriorly. There are no traces of ridges or sculpturing, but the body as a whole is scale-covered. Setae are few, short and scattered; there are a few upon the head in front of the eyes and probably a few also fringing the ventral borders of the head, for, although these are not actually seen, there is a series of minute depressions which suggest that setae or spinules had been present.

The head (fig. 27, 28) is sub-equal in length to that of first and second peraeon segments combined; as seen in profile, the front rises steeply, the dorsal line being almost straight. The emarginate anterior border is defined by a very slight ridge and upon the nearly vertical front the antennae are separated by a well-marked, long, triangular structure which suggests a vestigial rostrum (a similar development is found in *P. latipes*, while in *capensis* the ventral end persists as a ridge). The sub-ocular incisure is a narrow notch followed by a groove which is continued into the well-marked genal groove. Below the incisure, a sub-ocular area is outlined, its lower boundary being traceable onto the ventral surface. Spencer and Hall, in their *habitus* figure (l.c., pl. 3), depict below this a small but distinct triangular area which is actually a ventro-lateral part of the sub-ocular region. It overlies and extends forwardly beyond the fulcral process of the mandible. Behind the sub-ocular region, the ventro-lateral region of the head (which appears unarmed) is represented by a very narrow, smooth area immediately above the mandibular articulation; behind this the borders turn downward and widens into a deep post-mandibular extension of the gena which is very prominent in this species. In the figure by Spencer and Hall, the ventro-lateral border is incorrectly shown as a sinuous but practically horizontal line. Actually, the genal surface dips downwardly behind the mandible and is partly hidden by the overlying epipodite of the maxilliped. This condition is quite unusual, for, in Phreatoicids generally, this post-mandibular area is separated from the genal by a definite ventro-lateral ridge; in *P. terricola*, it differs, too, in that a deep slot is developed



FIG. 27.—*Phreatoicopsis terricola* Spencer and Hall.

N.B.—The dark mesial border of proximal endite (9) represents the close set rank of bases of

to receive the upper, lateral border of the epipodite of the maxilliped. In the figure the epipodite has been displaced, to expose this slit. The posterior region of the head shows no vestige of the cervical groove, the first peraeon segment having a somewhat sinuous anterior border which overlies the head, particularly at its ventral end, and is firmly united with it. The antero-ventral angle of the fused coxa projects in a rounded corner upon the head above the slot on the gena. The eyes, in comparison with the size of the animal, are small but are conspicuous as black sub-oval bodies on the dull cream-coloured head. There are from forty to forty-five ocelli, but the eye does not project prominently. In a freshly-killed specimen (a large male), examined under strong illumination, the eye appeared as a number (forty-four or forty-five) of mirror-silver surfaces bounded by black rings. In long-preserved material, they become dull black and may fade almost into invisibility. Spencer and Hall, comparing them with those of *australis* (where ocelli are few) suggested that the larger number found in *P. terricola* (stated by those authors as about thirty) were correlated with its large size. Since, however, other and far smaller Phreatoicids (e.g., *Amphisopus*, spp.; *Phreatomerus latipes*, etc.) may have actually larger eyes as well as a much larger number of ocelli, it seems more probable that there has been a marked *decrease* in the importance and size of the eyes in *P. terricola* as a consequence of the adoption of the cryptozoic and partly subterranean mode of life.

*Peraeon*. In its general proportions, the peraeon agrees with that of *M. tasmaniae* (G.M.T.), the segments being deep in comparison with their length. The segments appear practically parallel-sided and do not differ greatly in size; the second, third, and fourth are longest and are sub-equal; the third attaining the greatest width; fifth, sixth, and seventh decrease slightly in length; the first (although comparatively long) is actually shorter than the seventh but is unusually deep—almost equalling the seventh in that dimension. On the sternite of the first peraeon segment is a large conical boss between the coxae of the gnathopods. The ventral borders of some of the segments have a few setae, the produced angles nearly always bear a spine and the fused coxae, too, carry a sparse ventral fringe. Sub-marginally, there are remnants of anterior and posterior segmental setal rows. Such a feeble development of setae is doubtless related to the burrowing mode of life.

*Pleon*. In the relative shallowness of the pleon pleura, *terricola* again shows a resemblance to *M. tasmaniae*; in the former, the greatest depth of pleon is not quite twice the depth of peraeon and is less than the width of that region, so that the body is really sub-depressed. Of *M. capensis*, Barnard notes that the width of the peraeon equals the greatest depth of the pleon, which is twice that of the peraeon. In *australis*, on the other hand, the depth of the pleon may exceed once and a half the greatest width of the peraeon. This comparative shallowness of the pleon region in *Phreatoicopsis* may be considered as either the retention of a primitive condition, or, alternatively, the result of reduction of the pleura as part of the general modification of the body to a more vermiform shape in relation to the burrowing mode of life.<sup>(1)</sup> If this latter explanation be accepted for *Phreatoicopsis*, it would seem that it should be extended to *tasmaniae*, also, and we should be compelled to assume that this species, too, had had, in the course of its evolution, a burrowing phase. Since the extreme spininess of *tasmaniae* is

<sup>(1)</sup> In certain distinctly subterranean forms (*Phreatoicoides*, *Hypsimetopus*, and *Phreatoicus*) there has been a very evident tendency for the body to become sub-cylindrical (almost semi-cylindrical), the pleura nearly or quite obsolete.

opposed to that interpretation, the explanation for the occurrence of such proportions in such widely separated species as *capensis*, *terricola*, *tasmaniae*, and *kirkii* would seem to be that it is a very primitive characteristic, older even than *wianamattensis*. Depth in these pleon pleura is usually found associated with the actively swimming habit, and it seems probable that it may serve to enhance the effect of the sweeping stroke of the pleopods. Chilton (1891, p. 154) has suggested that the pleura serve merely to protect these appendages, but it should be noted that in practically all Phreatoicids the ends of the pleopods are freely exposed below the pleura, whatever the depth of the latter, and that the exposure is greatest in forms of subterranean habit where protection of the pleopods from abrasion would seem to be most needed. The inferior margins of the pleura are set with a fringe of setae, which is continued up the posterior border. In this latter region, the fringe is actually sub-marginal but the setae mostly stand erect and thus are readily overlooked.

The *tailpiece* in side view (fig. 27, 3s) appears as a truncated cone; the convex dorsal surface dips to a very slight concavity, behind which the actual posterior border rises in a scarcely elevated edge. This terminal elevation probably represents the telsonic projection of other genera; it is bent into a nearly circular piece (incomplete below) instead of persisting merely as a curved dorsal prominence. In the juvenile, there appears dorsally a distinct upturned part of this rim. The anal opening is a vertical slit guarded laterally by lips which fill the circular space included by the posterior border; these anal folds remain separate to the sternal level, an anterior part of the anal opening being continued on the sternal surface (fig. 27, 3v). The ventral edge of this hinder telsonic region lies in the plane of the sternal surface, there being in this species no recognizable telsonic pleural extensions. More anteriorly, there is a slight development of the pleura, but it is negligible as compared with that found in other surface-living Phreatoicids, and comes very near to the condition observed in blind and wholly subterranean genera. The free telsonic edge (including the posterior margin) is fringed with short setae, interspersed with occasional larger spiniform setae. Immediately anterior to the uropod, the ventral margin bears a powerful spine, forward of which, as it bends upward to pass into the nearly vertical anterior border of the piece, are five or six evenly-spaced stout and curved spiniform setae with which may be mingled a few finer setae. Separating obliquely the ventral from the posterior margin is the curved articulation of the uropod, from the dorsal (posterior) border of which the suture of sixth pleon segment to telson appears as the usual well-defined ridge which, in this species, is free from setae or spines. Examined by reflected light, the whole surface shows a regular granulation which suggests an armour of closely-fitting scales, and which, in profile, is seen as a serrated edge.

The *antennule* (fig. 27, 4) is stout, with distinct peduncle and a flagellum with from nine to twelve joints; these are cylindrical, mostly short and appearing almost square in outline. The appendage extends to about the middle of the fourth joint of the antenna and is sub-equal in length to its flagellum; olfactory cylinders are confined to the terminal four articles. The *antenna* is relatively short, barely one-third the length of the body, and its peduncle attains to a quite unusual robustness and actually exceeds considerably the length of its flagellum (as 5 : 4); the joints of the peduncle are progressively longer and less stout, the fifth being slightly longer than first and second combined, definitely longer than the fourth, but shorter than the combined length of second and third. The flagellum has, in fully-grown specimens, from twenty-seven to thirty-seven joints and is almost moniliform along the greatest part of its length, but near its end the joints become

longer and more slender; they bear setae each with a single sub-apical cilium (cf. *Eophreatoicus*). The entire appendage is rather more than twice the length of the antennule.

The *upper lip* (fig. 27, 5), which is based on a broad, moderately deep, asymmetrical epistome, is almost semi-circular, its ventral border being slightly flattened, almost emarginate and completely fringed with thick fur of inturned setae; on either side of this central region is a bushy fringe of setae extending round nearly to the epistome, in some specimens briefly interrupted at one or two points. The anterior face of the epistome is strongly convex, that of the upper lip rather flatter; under a high magnification, its outer surface appears scaly.

The relations of the *mandible* to adjacent structures is more readily to be made out in this than in other smaller species. Its actual articulation with the head laterally is along a nearly horizontal line forming a hinge occupying rather more than the middle third of the ventro-lateral border. In this part, the mandible is very thick, its dorso-mesial surface occupied by the relatively huge adductor muscle; further attachment for the muscle is provided by a strong apodeme, which rises from just within the ventral border of the opening and spreads fanwise in the head. At its narrow (mandibular) end, this apodeme is dark and heavily chitinised and seems to be actually articulated by a strong hinge joint (fig. 28, 6r). The anterior border of the opening for the muscle lies just against the hinder border of the base of the molar. The adductor muscle thus has its insertion within the mandible quite close to the origin of the molar. Both in front of and behind the mandibular articulation, the mandible is free but extends in contact with the head, a contact so close that it might appear to form part of the articulation. In front there projects the fulcral process, a large rounded boss which fits into a corresponding hollow provided in part by the labrum and in part by the ventral surface of the sub-ocular region of the head. Behind its articulation the hinder part of the mandible is greatly narrowed, this part of the edge resting against the anterior margin of the post-mandibular area. Here, too, is a large irregular 'ball and socket' articulation, but in this case it is the head, in the post-mandibular region, which projects and the hinder face of the mandible which is excavated into a distinct concavity. The postero-lateral edge of the mandible conceals the outer part of the maxillula; in *terricola*, this edge appears to be always uncovered, the epipodite of the maxilliped being narrow and its movement limited by the slot upon the gena.

The left mandible (fig. 28, 6l) has three very strong teeth on its principal cutting edge, the most ventral being particularly large, the proximal sometimes indistinctly subdivided into two; the lacinia mobilis, also with three dark-coloured, heavily chitinised teeth, lies quite obliquely, mesial to the main dentate edge. The molar is very stout and comparatively short, its sub-circular grinding face concave. On the right mandible, the outer edge shows four teeth, the lacinia mobilis is much less strongly chitinised and has but two (sometimes three) teeth; the molar is long, relatively slender with its end obliquely truncated to present a downwardly, directed grinding face. In both, the palps are stout, the first and second joints sub-cylindrical, the third conical and curved; the first has a small series of spini-form setae distally, the second joint with some constituting an external fringe and a few others scattered on the mesial surface, the last joint with a rank of three or four strong, minutely denticulate spines and the whole of its inner surface covered with setules.

The lower lip (fig. 28, 7) has a stout and fleshy basal region produced distally into an inner lobe scarcely distinct from the outer; it appears angular, the shape being liable to some alteration under pressure, and is set with an edging of fine

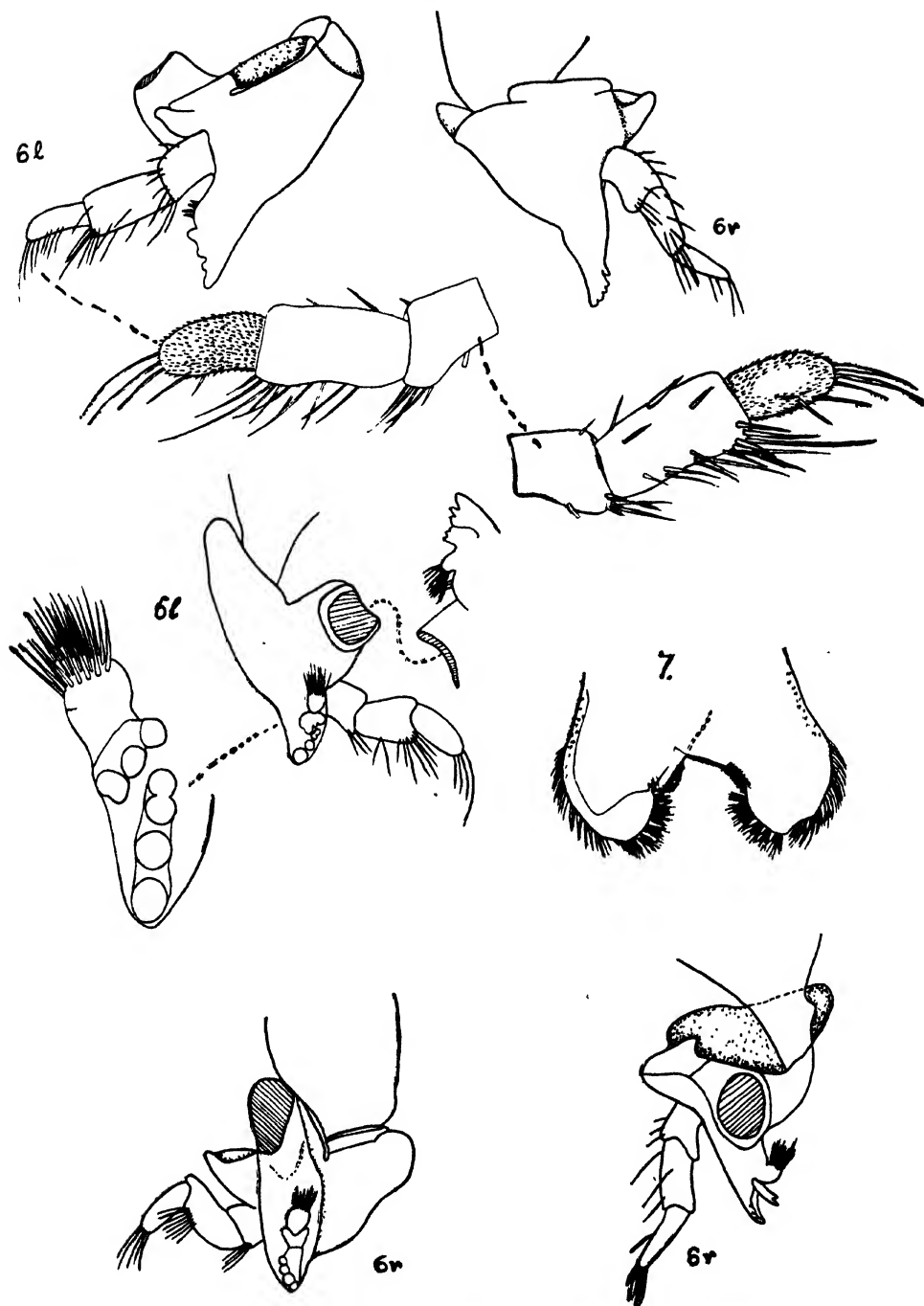


FIG. 28.—*Phreatoicopsis terricola* Spencer and Hall. Mandibles and paragnaths.

setae, but the outer is mesially incurved with dense fringing brush of setae. In this species, better than in most, can the character of this marginal fringe be made out as composed of stiff setae intermingled with close-set penicillae or setospines, about eight (perhaps more) in number. These penicillae appear to differ from the setospines which arm the inner endite of the maxillula chiefly in their shortness and greater bushiness. Upon the outer border of the lip is well developed a latero-distal fringe which fades away proximally into an imbricating (scale-like) edging of short setae.

In the *maxillula*, the structure described for *tasmaniae* by Sheppard from preparations cleared with caustic potash, can be made out quite readily in *terricola* if the appendages be examined by reflected light—the sutures and articulations being then plainly evident. It differs, however, from the account given of *tasmaniae* in that the third segment appears to be free. In the maxilla, some but not all of the parts may be distinguished in a similar manner. These appendages are, however, inadequately described by the statement that they 'bear a fairly close resemblance to *Phreatoicus australis*' (Sheppard, 1927, p. 118).

The maxillula (fig. 27, 8) consists of the two well-chitinized basal segments of which the outer proximal piece (identified as the second segment) is triangular in shape, and larger, relatively, than in other Phreatoicids. With its outer border, articulates the dark-coloured, heavily-chitinized outer lobe, clearly divisible into two regions—a proximal, pyramidal in shape with its whole mesial surface occupied by muscle masses and its outer edge setose—and a distal sub-quadrangular piece. This latter has a nearly straight outer border for about two-thirds of its length and is then bent mesially, the setae decreasing in length and fading out beyond its mid-length; the inner border sinuous and clothed with setae. Distally, it is obliquely truncated and ends apically in a curved, sub-triangular surface. At the wider, lateral, end of this surface, there is a row of four dark, heavily chitinized spines or teeth, followed by five curved rows of three apiece with a single mesial tooth at the inner apex of the triangular surface. The regularity of the third row (counting from the outer end) is broken by the presence of an additional tooth. Thus, there are twenty of these spines, but there is probably some variation, since Spencer and Hall describe it as having a triple row of spines and a total of twenty-five. The short rank of plumose setae on the surface of the lamella, in other Phreatoicids, is here represented by two stiff pectinate setae or, in some, by one stout and two more slender setae. The inner endite, shorter and barely half the width of the outer, is a much less robust structure with convex outer and concave inner border, both setose. The free (distal) end is evenly rounded and armed with a close rank of long, slender setospines, about eight in number, and a second row of seven setae, shorter and pectinate. At its proximal end, the broadening anterior and posterior surfaces of the lobe become widely separated mesially, and into the large hollow so bounded, great muscles enter to have their insertion. Still more proximally, the lobe is continued as a narrow wavy chitinous band inserted on the distal aspect of the first segment of the appendage.

The figure of the *marilla* given by Spencer and Hall (1896, pl. 4, fig. 6) requires some modification. The appendage (fig. 27, 9) is set very obliquely to the transverse plane, so that the proximal endite is forwardly directed, the two plates of the distal endite lying one behind the other nearly as much posteriorly as laterally. In several features (relative proportions of lobes, disposition of setae, etc.) it seems to retain a primitive condition. Thus the three endites are approximately of the same length, and the inner endite has a relatively wide inner, concave, and sub-triangular surface presented antero-mesially. Its anterior sub-marginal fringe of setae, which may be either simple or pectinate, passes distally into a scattered

group which spreads to the outer edge of the apical tuft. The postero-mesial border has a dense fringe of long filtratory setae (fifty or sixty in number), set in a close comb-like row, extending from the proximal to the distal end where it passes into the apical tuft which arms the evenly-rounded apex. Immediately sub-marginal (posterior) to this comb is a third rank of setae, stiff, pectinate at their ends, more widely spaced and set at a different angle to those of the filtratory series. The series evidently forms a kind of protecting grill interposed between the filter setae in front and the brush setae of the maxilliped behind. This row, too, seems to merge into the apical cluster, which is dense and consists of mixed pectinate and simple setae with some partly plumose; one or two of the more lateral spines being stouter. The outer border of this proximal endite is fringed by a continuous line of setae. The two endites of the third segment are both strongly chitinised, are unusually long and narrow (cf. *typicus*), the inner being a little shorter than the outer, and bear on the rounded apices *two exceptionally stout* pectinate or denticulate spines surrounded by a number of typical slender setae. Both of these endites present an antero-mesial concave surface, and upon the outer of these are some finer, but equally long (or even longer), pectinate setae. The retention of such an armature of setae along much of the inner (mesial) aspect of this lobe is a feature, also, in *E. kershawi*, *P. typicus*, and *M. capensis*, though in these it is less strongly developed. In addition, the anterior surface of both inner and middle lobes is covered by a fur of setules, a condition almost peculiar to this genus.<sup>(1)</sup>

Between the bases of the maxillae lies a well-developed median process (fig. 2B).

*Maxilliped.* The condition of this appendage is shown in (fig. 27, 10). It is extremely robust, the joints well rounded and relatively short; the coxa is large, basis wide and unusually short, merus, carpus, and propod strongly expanded, the latter rounded and expanded mesially. The epipodite, of somewhat irregular shape, springs from a wide base and has an almost complete fringe of very short setae and some scattered spinules around the outer border. The basis is produced into an exceptionally wide inner endite which extends forwardly between the proximal endites of the second maxillae. The mingled pectinate and brush setae which fringe the inner (dorsal) border of this plate form a continuous series in a double, or possibly a triple, row from its proximal end to its rounded apex; the setae, which are densely clustered apically are continued around to the posterior edge of the endite and extend also onto its outer (lateral) surface, where it is covered by the palp. Sub-marginally, these setae stretch along the ventral border of the endite, a number of them being modified into coupling setae. Four or five of these are very strongly curved, although apparently not provided with apical barbs or hooklets. The several joints of the maxilliped are armed distally with one or more incomplete bands of setae, while there is a fringe, also, along the median and lateral borders. In addition, stout setae are scattered plentifully over the ventral (morphologically, the posterior) surface of the several joints, a condition not observed in other genera. In the one spent female dissected, the coxal lobe projects almost directly posteriorly (i.e., at right angles to the hinder surface of the coxa of the maxilliped) as a narrow crescentic piece, its free convex border set with a fringe of long setae, the lobe itself appearing stiff and immobile. The brood-pouch which follows is made up of tough chitinous flaps, not very greatly expanded, those on second, third, and fourth peraeopods, all more or less alike; the first and second plates on the left overlapped externally the opposed pieces, while in the third and fourth oostegites the arrangement was reversed.

<sup>(1)</sup> Elsewhere seen in *S. ambiguus* and *U. pearsoni*.

On the gnathopod, the oostegite is very unequally bilobed, the larger posterior piece forming the anterior wall of the brood-pouch, the quite small anterior portion being bent in a plane practically at right angles to the hinder lobe and forms a concave, almost sheath-like, structure underlying the basal portion of the maxilliped. Between these, of opposite sides, project obliquely backwardly these oostegal (coxal) outgrowths of the maxillipeds.

*Peraeopods.* Sheppard states that in the female the coxal joints of second, third, and fourth peraeopods are free, a statement doubtfully confirmed by the examination of two large specimens. Of this anterior group, the peraeopods resemble those of *capensis* and of certain Tasmanian (*tasmaniae*, *brevicaudatus*, etc.) and New Zealand species (*kirkii*) in the rounded (cylindrical) condition of the joints; the basis of the hinder three pairs shows a little expansion. If the rounded condition be primitive, it must be of very great antiquity, for the Triassic fossil species *wianamattensis* had already acquired a very notable expansion of almost all of the joints of the peraeopoda. If, on the other hand, the rounded condition has come about by the loss of the plate-like portions consequent upon the adoption of the burrowing habit, it is obvious that it might have been attained independently in *Phreatoicopsis* and the several subterranean forms found elsewhere upon the mainland of Australia, in Tasmania and New Zealand. That would not explain, however, the occurrence of this condition found in certain of the Great Lake species; unless we are to suppose their present habit to be a reversion to a free-living condition which has followed upon a not too prolonged burrowing stage. *P. terricola* differs from *tasmaniae*, however, in the relative shortness of its peraeopods in the hinder series, in which particular it comes nearer to *M. capensis*, to which species, indeed, it bears many other resemblances. The longer legs of *P. tasmaniae* may be related to a more active running habit, for it may be found freely in hollows under stones, logs, etc., whereas most surface-living species live more or less buried in mud beneath liverwort or moss. The peraeopods are practically without setae or spines on the anterior border, but sparse spines fringe the posterior edge of the joints. In the hinder group of peraeopods a few spines occur on the anterior border also.

*Pleopods.* In the exopodite of the first pleopod, *terricola* has not departed greatly from that which is considered as the primitive shape—a long, sub-oval lamella, such as is seen in *M. capensis*, *M. tasmaniae*, *E. kershawi*, and *A. lintoni*, fringed in all of these forms with setae along the outer border and the distal half of the mesial border. But, whereas in *capensis* and *kershawi*, the endopodite has a similar shape and size (also, presumably, the primitive condition), in *M. tasmaniae* and *lintoni* the endopodite has dwindled somewhat, though retaining its narrow, sub-acute shape, in *terricola* it is markedly shortened. (It is of interest that in *Phreatomerus latipes*, although the pleopod lamellae are alike and equal, they have, as a series, become short and broad, presumably in conformation to the sub-depressed broadened condition of the body.) The sympodite is stout, dark-coloured, and heavily chitinized and is divided by a deep groove into two regions; from the distal spring the two lamellae and two lobes—one mesial (the coupling lobe), sub-triangular with apex directed distally and surmounted by three or four simple setae—the outer, possibly a vestigial epipodite, almost semi-circular, with crenate edge set with from ten or eleven long, simple setae. Lying posterior to this (i.e., in a position which such a lobe has normally to an epipodite) is a proximo-lateral extension of the exopodite which is developed in other Phreatoicids only on second and succeeding pleopods. More proximally, is the vestige of an inner joint, indicated laterally by a small swelling crowned with three or four stiff, pectinate setae.



In the female, the second differs from the first chiefly in being slightly longer and broader and in that the exopodite is two-jointed, its distal joint being, in shape a narrow oval. The endopodite is longer than that of the first pleopod and tends to be tri-lobed, perhaps the result of an incomplete separation of a wider basal and a narrower distal piece, in this resembling the shape of the endopodite of the first pleopod in the male. The sympodite differs little, the coupling lobe is rather longer and its apical portion somewhat bent and the vestiges of an epipodite rather larger.

In the male (fig. 27, 13(2) ♂), the second pleopod shows the modified endopodite clearly marked into two regions—a proximal, broad, sub-triangular or nearly semi-circular, from its distal edge springing the respiratory lamella laterally and the penial stylet mesially; the latter is quite stout, curved, not noticeably tapering, and longer than its related lobe and ends in a pointed apex devoid of long spines or setae—thus being intermediate between the Amphisopine and the Phreatoicine condition. Its apical region, however, may be set with a number of short spinules, and in one specimen, on one side only, was found a short rank of stiff setae.

The third, fourth, and fifth are alike in both sexes and differ little in size from the second, but the epipodites which are borne on a short stalk are progressively smaller and change in shape from reniform to oval and to round.

The *uropod* (fig. 27, 3s) is stout; its peduncle short and broad, concave dorsally. The inner edge is well raised and is spinose, having seven or eight strong spines, the last two, mounted on a well-developed distal process, stronger than the rest (cf. *pearsoni*). The outer, and much lower, edge is furnished with but three stout spines. The ventral border of the peduncle is armed with an anterior spinule followed by three spines each accompanied by a setule; the single terminal spine beneath the insertion of the outer ramus is strong and entirely free from teeth or pectinations. It may be flanked by a second more slender simple spine. Of the rami, which are strongly curved, the inner is much the longer and greater in length than the peduncle; both are stout, produced into a long sharply-pointed end, the inner armed laterally with one or two spines and a few scattered setules.

*Colour.* The animal in life is translucent with pale bluish-white tint, the intestine showing through as a dark shadow; cadmium yellow markings always present on head and variably on sixth and seventh peraeon segments and first, third, and fourth pleon segments. When present on the body, the yellow colour appears in narrow transverse bands, generally near the hind border of the segment; in most specimens, these bands were restricted to the hindmost two segments of the peraeon. In spirit material, the colour fades to a dull creamy white.

*Size.* Spencer and Hall record this as 45 mm. Two or three specimens have been taken which in life slightly exceeded this.

*Occurrence.* Otway Mts., on hills overlooking the Gellibrand R. (Spencer and Hall). Mt. William (near Ararat) and the Grampians (Raff), but as suggested below, the specimen from the latter locality should perhaps be assigned to a new species.

Of the specimens attributed to this species, there have been examined (in 1928) all which were then in the collections of the Museums of Melbourne and Adelaide obtained from the Otway Ranges and also from the Grampians. In addition, a couple of preserved specimens were given by Mr. Searle of Melbourne and a quantity of living material collected by Professor Wadham of the University of Melbourne, to whom the writer desires to take this opportunity of expressing very sincere gratitude. Of a total of twenty-eight large specimens examined, thirteen were males and, of these, three showed tough, or calcified, and spatulate

incipient brood lamellae closely adpressed to the sternite, while in another three the lamellae were present but more weakly developed. Fifteen were undoubtedly females, but no fewer than five had penes well developed. These must develop quite early, for they were evident in one small male specimen, in which the penial stylet, although indicated, had not become distinct from the endopodite of the second pleopod.

Since the gnathopod is alike in both sexes and there is no sexual modification of the fourth peraeopod, the determination of the sex in such cases can be made only by examination of both the seventh peraeopod and second pleopod.

In at least six partly-grown examples showing the first stage of the brood lamella, the pleopods were of the male type and particularly long penes were found arising from the coxa of the last peraeopods. On large spent female, with fully-developed brood-pouch, however, showed penes present on segment seven, although the second pleopod was without penial stylet. Subsequently, four others, both mature and immature females, were found with moderately-developed penes. These apparently differ slightly in shape from those seen in the male, being rather shorter and more flattened.

One female of 39 mm. was ovigerous, the brood-pouch containing about thirty embryos with some *Temnocephala*! A second female (30 mm.) exhibited a well-developed external hermaphrodite condition. In this specimen, the oviduct opened at the median end of a long ridge which seemed to be a mesial extension of the coxa.

It was noted of *Eophreatoicus* and of *Amphisopus* that in the male there is a development upon the maxilliped comparable to, but smaller than, the normal oostegal flap on that appendage in ovigerous females.

Of the specimens taken in and near the Grampian Mountains, none examined seemed mature. In several features there appeared differences from the condition recorded for *terricola*, but the material was too scanty to warrant the institution of a new species.

### **Uramphisopus, gen. n.**

Body robust, sub-cylindrical, fusiform. Head relatively long with short and wide sub-ocular incisure, cervical groove partly concealed by coxa of gnathopod, and with small posterior process; eyes comparatively small but prominent, apparently undergoing reduction; both head and peraeon wider than deep, anterior three peraeon segments notably shallow, pleon appearing compressed, the full depth being once-and-a-half as great as the width in that region; tailpiece comparatively short, apex short and wide, abruptly upturned.

Antennule relatively long, but flagellum with few joints; antenna of moderate length; lacinia mobilis of right mandible small, united with spine row; maxillula with few (four) setospines on inner endite, maxilla with endites of third segment short; gnathopod strong; bases of hinder peraeopods only moderately expanded; pleopods with stiff setae on anterior face of exopodite, penial stylet long, armed terminally with spines; uropod with huge mesial process which can be apposed to its fellow of the opposite side, and then completely closing the telsonic arch; the apical spine beneath insertion of rami, stout and notched, rami without terminal movable spines.

Genotype. *Uramphisopus pearsoni*, sp. n.

The relative proportions of peduncle and flagellum of the antennule found in this genus are quite unusual. The eye is small with few but unusually large

ocelli—its condition suggests approaching obsolescence. The occurrence of abundant setae on the face of the exopodite lamella is a feature occurring in several Amphipsopine genera—outside of which it is practically restricted to *brevicaudatus*. The telsonic apex is strikingly like that of *brevicaudatus*; it differs from that species, however, in the retention of a small lacinia mobilis on the right mandible; the condition of the endites of the maxilla comes nearest to that found in *Phreatoicopsis* and *Synamphisopus*, in which genera, also, there is a large mesial process upon the uropod—but in *Uramphisopus* this latter reaches its maximum development. Since a much smaller but quite distinct process is also found in *Hyperoedesipus* and *Phreatoicoides*, it is possible that it represents a device of value to burrowing forms; but the condition in the two last-named genera suggests a retrogression in the structure which may be due to the partial abandonment of the burrowing habit for life in underground waters.

*Uramphisopus pearsoni*, sp. n.

(Figs 29, 30)

*Male.* *Body* robust, sub-cylindrical; in dorsal view, fusiform, having a nearly uniform width from second to seventh peraeon segments (male) and tapering both to head and tail; its length six times its greatest width; not sculptured nor ridged, spines absent, setae scanty but occurring rather more abundantly in the pleon where they become longer and finer.

The *head*, which is as long as the combined length of first and second peraeon segments, measured in mid-dorsal line, is free from the first peraeon segment; it is wide through its whole length, and deep; its anterior border only shallowly emarginate; eye, of moderate size but scarcely prominent, and apparently by way of becoming obsolete, there being only about fourteen or fifteen rather large ocelli, laterally placed, in some specimens without pigment;<sup>(1)</sup> the distance between eyes about six times their long diameter, this inter-ocular surface being scarcely concave. The sub-ocular incisure is well marked but very shallow, gaping widely, its ventral margin extended as the long upper edge of a distinct sub-ocular or antero-lateral lobe of the head. The hollow behind the eye is shallow, the genal groove short. The ventro-lateral border of the head runs slightly above the mandibular articulation and dips down into the post-mandibular region so that there is only a small ventro-lateral (maxilliped) area below. The pre-mandibular part of this border is short, the mandibular articulation long, the post-mandibular area short and deep, overhung by the coxa of the gnathopod and produced forwardly into a very small 'posterior process'. The cervical groove rises from the ventral border but, at its lower end, is hidden by the overhanging coxa. It is separated only by a ridge from the intersegmental groove which marks off the first peraeon segment from the head. Higher up, on the side of the head, the groove deepens but does not meet its fellow dorsally, so that in this species (unlike *brevicaudatus*) the maxilliped segment is not quite completely marked off from the head.

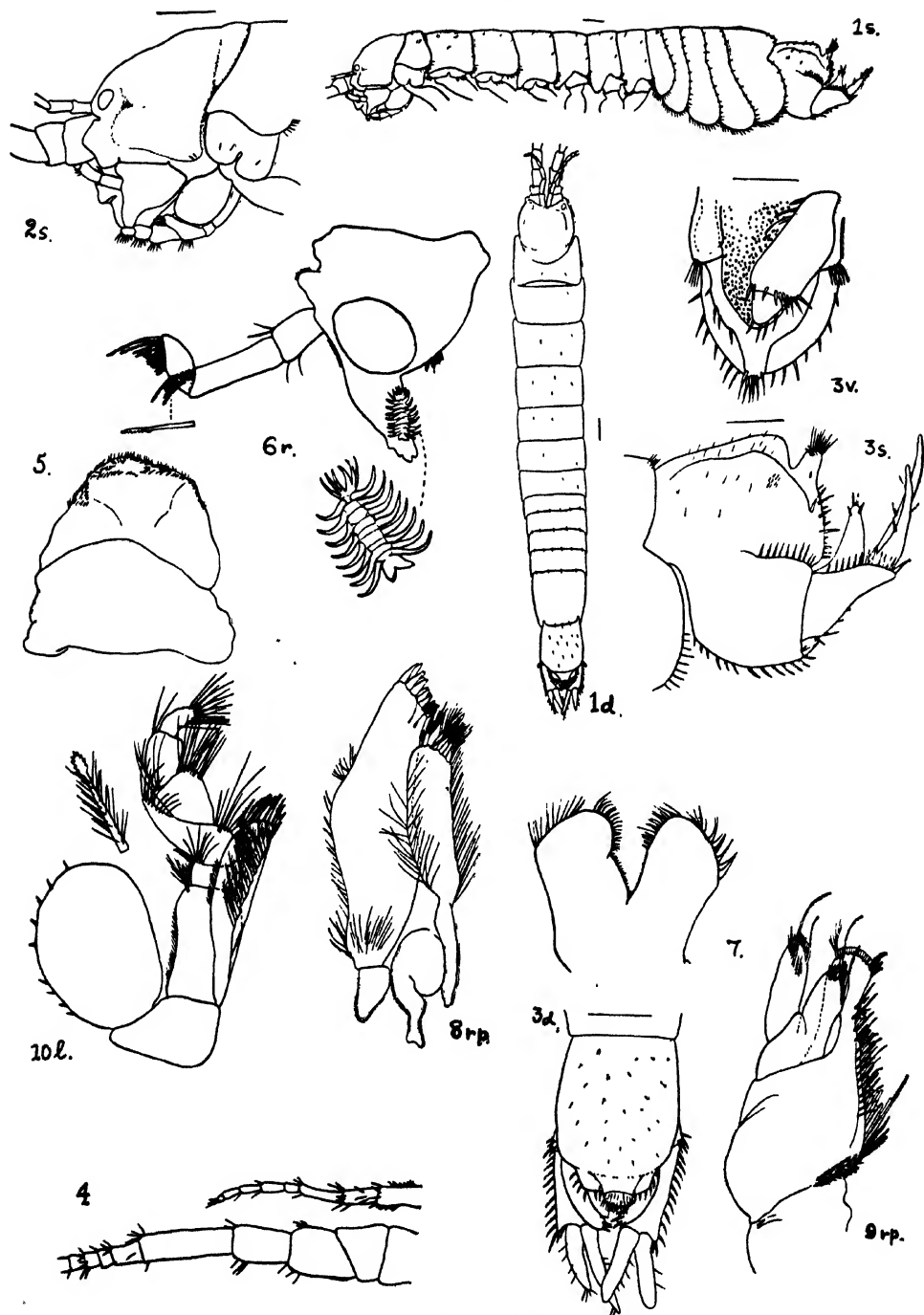
First peraeon segment very short dorsally, expanding somewhat below where it is much wider than the coxa of the gnathopod, its hinder angle rounded. In dorsal view it is seen to embrace the side of the head in a fashion reminiscent of *Phreatomerus latipes*, but differing markedly from that species in that this segment is not fused with the head. Transversely across the sternite is a stout ridge,

(<sup>1</sup>) It is, of course, possible that this appearance is due to post mortem change, and marks an early stage in the maceration of these specimens in the stomach of the trout; it seems, however, to be a normal condition.

against which the coxae of the maxillipeds rest. In the first, as in all the succeeding peraeon segments, the postero-lateral angle is fringed with setae. In the second to the seventh peraeon segments, the antero-lateral angle, also, is produced downwards in front of the related coxa and is, similarly, seta-fringed but in the first peraeon segment such a free anterior lobe is absent and the coxa, of unusually large size, appears firmly fixed to the segment. The second, third, and fourth segments are sub-equal and longer than the fifth to seventh (which also are sub-equal), but the second and third are distinctly shallower than the others. The coxae of the first to fourth peraeopods appear completely fused with related segments, but in the fifth to seventh they are clearly defined and may be free.

The pleon segments short, the first shortest, the first and second together about as long as seventh peraeon segment; the third and fourth increasing slightly in length; the fifth not very long but still about equal to third and fourth combined; the tailpiece, including telsonic projection, is scarcely longer than the fifth. The pleura of first pleon segment shallow, scarcely extending below the level of the seventh peraeon segment; the second to fourth expanding ventrally, so that they are longer than their segments; that of the fifth is much longer, meeting the tergum behind in a rounded notch. They are all bordered ventrally by long, slender setae, this fringe in the second to fifth segments being continued upward along the posterior margin of the pleura. The tailpiece, in profile, shows a nearly straight dorsal line, separated by a sharp notch from the terminal telsonic projection which is abruptly upturned; this is, in this species, very short and wide, narrowing apically, its hinder end is continued downward into a flattened posterior surface (fig. 29, 3v), the ventral border of which forms the upper boundary of a narrow arch, of which the sides are formed by the telsonic pleura. These, seen in side view, are almost straight and bear numerous (eight to ten) spines, one or two of which are slightly stronger than the others; immediately sub-marginal to the fourth is another slender spine. The vault of this arched end of the body lies practically at the level of the sternite, so that the anal opening is not terminal as in *terricola*, but postero-ventral, but in any case it is normally hidden by the huge paired mesial processes of the uropods which can be apposed in such a way as practically to close this telsonic arch behind. Ventrad to the telsonic pleuron, the margin is occupied for a considerable stretch by the insertion of the uropod, the peduncle of which is unusually broad; from the upper end of the insertion a sutural ridge extends antero-dorsally halfway across the tailpiece. The ridge is armed by a dozen long, stiff spine-setae. The pleuron of the sixth pleon segment immediately anterior to the lower end of the insertion of the uropod is convex and bears numerous (about a dozen) long, stiffly-curved setae, almost all of which are apically toothed. The series ends in one immense spine, with three or four slender flanking setae; the condition of this region being strikingly like that of *ambiguus*. Dorsal to this row of setae, the pleuron is excavate, producing a distinctly concave anterior border. The dorsal edge of the telsonic apex is armed with one pair of spines and a close tuft of probably a dozen very long setae between.

*Appendages.* In the mature male, the antennule (fig. 29, 4) presents a condition not found in any other Phreatoicid. It is relatively long, as compared with the antenna (in this agreeing with *Amphisopus*, *Phreatomerus*, etc.), reaching in its natural position practically to the end of the peduncle of that appendage, but of its length, its peduncle contributes three-fifths, stretching nearly to the end of the fourth joint of peduncle of the antenna. Moreover, the three joints of the peduncle are sub-equal—the second joint slightly the shortest. The first joint is clothed with short, fine setae and appears unusually wide, this being due to its production into a lateral keel. In immature specimens the antennule may fall a

FIG. 29.—*Uramphisopus pearsoni*, sp. n.

little short of the length of the antennary peduncle. The *antenna* is of but moderate length, being scarcely as long as head and first four peraeon segments; its peduncle stout—the first and second joints sub-equal, third joint as long as fourth, fifth joint barely three-fourths of combined length of third and fourth; flagellum with twenty-two joints (male) once-and-a-half the length of peduncle; the first joint of the flagellum, although relatively short (only one-third of the length of the fifth joint of peduncle), is, nevertheless, *much* longer than any subsequent joint.

The *epistome* is strongly projecting and overhangs the *labrum* (fig. 29, 5), which is markedly asymmetrical; it is roughly semi-circular in outline, but a strong sub-median ridge lies all askew. The *mandibles* are particularly massive, with powerful molars; the short, stout palp has the first joint with few setae, a little longer than the third, the second, with a small apical tuft of setae, almost twice the length of terminal joint, which bears a row of pectinate setae along one-half its length. The left mandible has a cutting edge with four strongly chitinized teeth and a short, wide lacinia mobilis, also, with four teeth; on the right appendage the primary cutting edge has four teeth and its spine row is attached unusually far distally; the lacinia (fig. 29, 6r) is no longer distinct, but is a small bi-dentate structure united with the distal (outer) end of the spine row, its teeth minutely denticulate. Posterior to the base of each molar lies a curved row of setae. The fulcral process is pronounced and apparently setose.

The *lower lip* shows practically no differentiated inner lobes, while the outer gape widely and appear angular rather than rounded with sparse fringing setae.

*Maxillula*. The outer (distal) endite (fig. 29, 8rp) is strong and presents a somewhat unusual shape, being bent and narrowing sharply to its apex. It is armed with ten to twelve simple spine-teeth in two rows with a single short seto-spine, just external to the innermost tooth. On the same (posterior) face of the lamella are two long plumose setae, rising near to the mesial edge. On the inner endite, which may widen slightly to its apex, are four stout setospines with two slender spines (simple or feebly-plumed) corresponding in position with the two simple setae of Chilton's description of *australis* (1891, p. 158, pl. 23, fig. 7). The outer margins of both endites and the entire mesial border of the inner endite are fringed with fine setae.

The *maxilla* (fig. 29, 9rp.) is notable for the relatively great development of the proximal endite. It extends as far distally as the outer of the two distal endites; both of these are small and short, the inner of the two particularly so, recalling the condition found in *Phreatoicopsis* and *Synamphisopus*. The outermost rises from an especially pronounced pedicel and gives to the appendage an appearance strikingly like that of *Apseudes* (in which genus the outer member is interpreted as a palp). Upon the proximal endite, the antero-mesial edge bears a close-set row of filter setae, supported by the usual posterior sub-marginal row of finely-pectinate setae. Both ranks end a little short of the apex which is rounded and bears a single row of spines, coarsely denticulate mesially but becoming feebly plumose laterally. Both of the distal endites are obliquely truncated and bear a short rank of more or less finely-denticulate spines; sub-marginally on the posterior face is a rank, variable in its length of simple setae.

*Maxilliped* (fig. 29, 10l). The coxa is large and backed posteriorly by a strong transverse ridge on the sternite of first peraeon segment; the basis is very stout and of moderate length, with the usual single plumose seta at its outer distal angle; its endite is fringed with about ten plumose setae. These are restricted to the distal half of the mesial edge and each has a very stout base; the distal four are peculiar, being flattened apically in a manner which has been observed

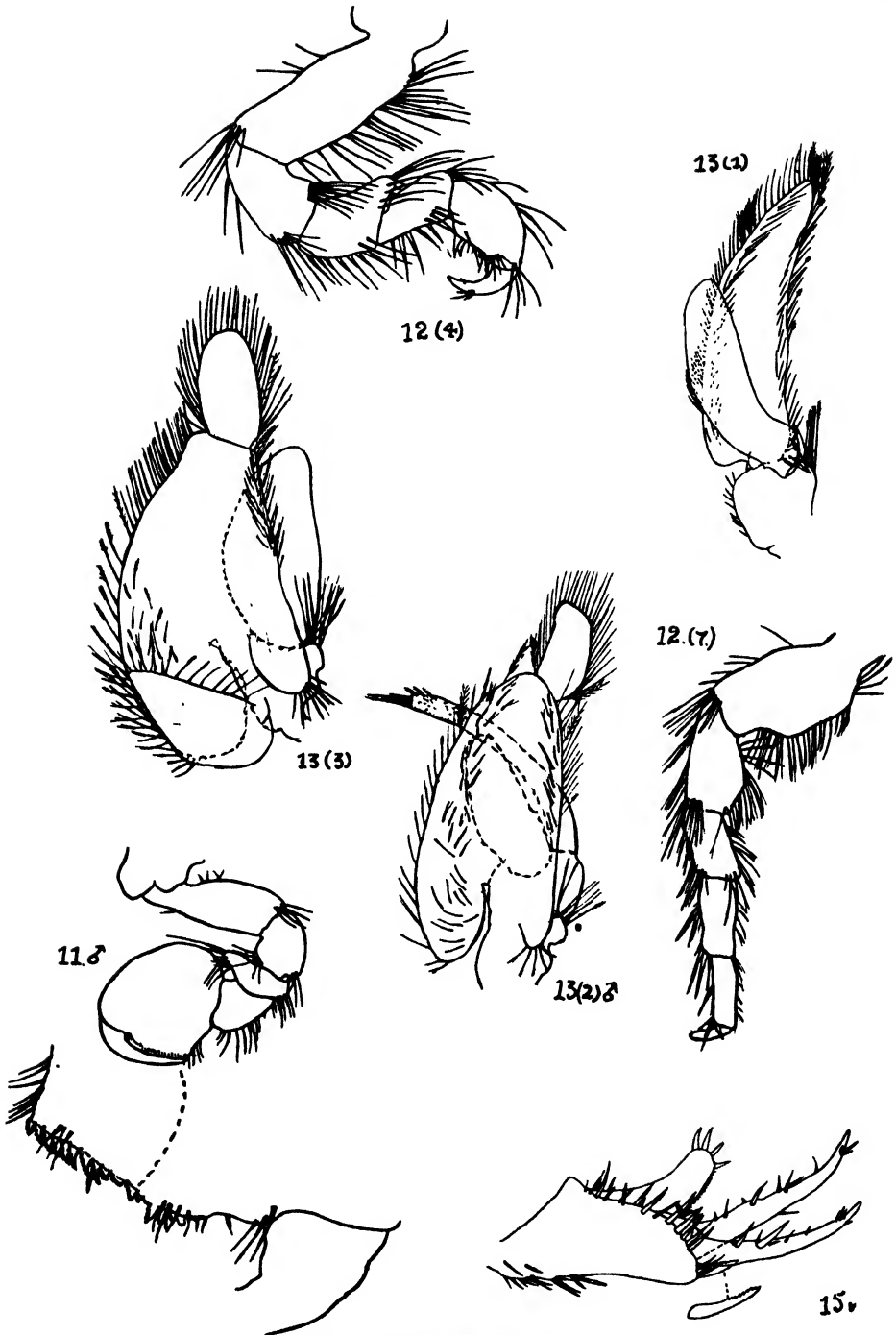
in no other Phreatoicid. The endite itself appears unusually long, perhaps due to the fact that the palp, though stout, is relatively short. The epipodite has a sparse fringe of spinules laterally, and extends distally just beyond the basis.

The *gnathopod* (fig. 30, 11) is very short and stout, the basis almost without setae, except for a proximal tuft on the anterior border which is, however, not always present; the ischium is relatively short, the merus strongly produced anteriorly, its free end fringed with long setae; the hand is very strong, the greatest length of the propod actually exceeding that of the basis and its width is sub-equal to the length of that joint; the anterior border of the propod is strongly convex, the posterior much shorter, about two-thirds only of the length of the palm which is nearly straight and bears an uneven rank of short strong spines, each dentate on its posterior edge; the dactyl, nearly as long as the basis, is little curved, its palmar border fitting closely against these spines.

*Peraeopods.* The second and third peraeopods are alike, except that the basis of the second has, in addition to its proximal tuft of setae, a rank of short setules on its anterior border. In the succeeding limbs, the basis is fringed along both borders with longish flexible setae. The fourth (fig. 30, 12(4)) is rather more obviously capable of gripping, but even in this appendage the spines on the propod are not noticeably long and strong, while those on the carpus are rather stouter; it is possible, therefore, that here, as in *Amphisopus*, the terminal three joints together function as a clasping hand. The fifth, sixth, and seventh (fig. 30, 12(7)) peraeopods are, also, much alike, except for the increasing length of limb and degree of expansion of basis. In general, the joints are fringed with flexible setae, but on the distal joints of sixth and seventh, these may be partly replaced by stout spines. In the sixth the merus is somewhat produced distally.

*Pleopods.*<sup>(1)</sup> While these lack the large development of the sympodite of the first pleopod they, nevertheless, come near to the condition found in *brevicaudatus* in the occurrence of abundant stiff, simple setae on the anterior face of the exopodite, a condition found elsewhere in *Mesamphisopus*, *Amphisopus*, and *Paramphisopus*. In the first pleopod (fig. 30, 13(1)), the sympodite is much shorter than in the corresponding appendage of *brevicaudatus*; its distal mesial angle produced into a definite lobe armed with nine or ten long, slender, doubly-pectinate setae. For the most part, these entangling setae are marginal, whereas in *brevicaudatus*, the marginal pectinate setae are fewer, but there are several tufts of stiff, simple, sub-marginal setae. The outer border of the sympodite in *pearsoni* is expanded and bears a fringe of short setae. The exopodite is long and lanceolate, the setae on the distal third of the outer border plumose, these continuing around the apex onto the distal end of the inner border, the rest of the setae on this border being finely pectinate. The sub-marginal fringe consists of long, simple, flexible setae. The endopodite is rather more than half as long as the exopodite and is greatly swollen, but in the specimens examined it is edged by a delicate membranous border. This appearance may be a consequence of incipient digestion in the stomach of the trout. In the second pleopod (fig. 30, 13(2)♂), the fringe of plumose setae is rather more extensive, the sub-marginal setae tend to spread well in onto the face of the lamella, particularly on the proximo-lateral lobe. There is a small proximo-mesial exopodite lobe almost devoid of setae. In the male, the penial stylet is long with a series of seven spines, of which four are terminal, diminishing in length and followed by three much shorter spines placed sub-terminally; the distal end bears numerous setules. The related endopodite is rather short and its basal region very robust, giving the sympodite an appearance

(1) This species being from the Great Lake (Tasmania) was originally compared in detail with *brevicaudatus*, with which it appeared to have much in common.

FIG. 30.—*Uramphisopus pearsoni*, sp. n.



of unusual length; the coupling lobe bearing pectinate entangling setae is pronounced, situate just proximal to the origin of the endopodite. In the third pleopod (fig. 30, 13(3)), the endopodite is relatively longer, practically as long as the basal joint of the exopodite; this is, on both its lateral and mesial borders, greatly produced proximally; the lateral fringe of plumose setae is restricted to the distal half of the appendage; sub-marginal setae form a fringe on the distal half, only, of the inner border, but are abundant and scattered on the latero-proximal part of the joint, some of these being pectinate; entangling setae arise in two widely separated groups proximally and distally on the sympodite; the epipodite is large and sub-triangular, arising by a very narrow stalk, and is fringed with long, doubly-pectinate setae.

The *uropod* (fig. 30, 15) is notable for the exceptional development of the mesial process. The peduncle is stout, very deep basally, its outer border tapering away distally. On the inner edge there is a great flattened process, rounded apically and armed with four stout spines; it is shorter but much stouter than the two rami and gives to the appendage a triradiate appearance seen in other Isopods, chiefly in the Cymothoidae. The two rami are sub-equal, slender, and tapering, armed with a few spines and setae. The ventral edge of the peduncle bears on its anterior half several tufts of mixed spines and setae; the distal half is unarmed, except at the apex, which bears one very strong spine dentate along half its dorsal border and flanked by three or four more slender, simple spines.

The *typhlosole* in this species is large, circular in section.

*Colour.* All of the specimens examined have been taken from the stomach of trout. They are almost invariably pale brown in colour, and all appear to be males.

*Size.* This is probably the most robust of the Tasmanian species; its maximum length is about 22 mm.

*Occurrence.* Probably a burrower in the floor of the Great Lake. Its colouring is uniform and agrees closely with that of the coating of mud found on many specimens; the eyes are evidently undergoing reduction. It appears rarely in collections (three stomachs only contained representatives of this species) and has never, apparently, been taken in any other manner.

The species is named in compliment to Dr. J. Pearson of the Tasmanian Museum.

The type is lodged in the Tasmanian Museum.

#### Sub-family V. HYPsimETOPINAE

Body vermiform; head long with cervical groove, eyes wanting; antennule short, antenna long; first peraeon segment long, free from head; telson truncated. Gnathopod attached well behind head, differing in the two sexes; fourth peraeopod sexually modified; pleopods without coupling hooks; endopodites reduced and epipodites present or wanting; penial stylet short, strongly bent and unarmed apically; uropod having rami with fixed terminal spines.

Two genera with four species are placed together here and are doubtfully included in the Amphisopidae. All are specialized forms which lead a subterranean life, probably adopted at a very remote period. Their distribution somewhat parallels that of the Phreatoicopsinae, two species being found in Victoria from the Otways and Gippsland, the other two from West Tasmania—a very ancient geologic formation, probably at least as old as the Great Lake.

The elongation of the first peraeon segment is probably a consequence of life in underground crevices, which has led to the vermiform condition—the shortened pleon is probably another result of that mode of life. In the pleopods *Hypsimetopus*

retains on the *endopodite* of the first pair a few plumed setae, evidence of a one-time natatory function, as well as the usual complement of three pairs of epipodites. The *Phreatoicoides* species have lost epipodites as well as most or all of the plumed setae from the *exopodites*, the endopodites being wholly unarmed.

### **Hypsimetopus Sayce**

Sayce, 1902, p. 219.

*Body* slender, sub-cylindrical; *head* longer than deep but shorter than the combined length of first and second peraeon segments, without eyes or sub-ocular incisure, with transverse groove; first *peraeon* segment free from head, first four peraeon segments sub-equal; *pleon* short, less than half the combined length of head and peraeon, *pleura* little developed, tailpiece longer than fifth pleon segment, narrow posteriorly and truncated, the end armed with two stout spines and a cluster of setae not appearing in lateral view.

Antennule short; antenna long; epistome forming a conspicuous transverse ridge; right mandible probably with reduced lacinia mobilis; inner endite of maxillula with six setospines and one simple spine; maxilliped with palp long, epipodite sub-pentagonal. Gnathopod of male with both basis and ischium short and broad, propod very stout; fourth peraeopod not sexually modified; hinder peraeopods with dactyl long; pleopods largely exposed, both exopodite and endopodite of first pleopod with plumose setae, second pleopod of male with penial stylet short, strongly curved, tapering and unarmed; epipodite on three hindmost pleopods, endopodite not markedly reduced; peduncle of uropod raised on its inner dorsal edge, rami shorter than peduncle apical spine fused with rami.

Genotype. *Hypsimetopus intrusor* Sayce.

### **Hypsimetopus intrusor Sayce**

Sayce, 1902, p. 210, pls. 18, 19 (*Hyp. intrusor*).

Sheppard, 1927, p. 121 (*Hyp. intrusor*).

With the characters of the genus, to which the following may be added:

*Body* smooth and practically free from setae, except on the tailpiece. *Head*, eyes wanting, with a few setae on anterior border; first peraeon segment slightly produced antero-ventrally. Antennule not reaching end of fourth joint of peduncle of antenna, flagellum with seven joints, slightly swollen terminally. Antenna long, with more than thirty-three joints in the flagellum. Left mandible with four teeth on primary dentate edge, three on lacinia mobilis; on the right mandible between spine row and primary dentate edge (with four teeth) is a 'single stouter, simple spine' which can be nothing but a lacinia mobilis greatly reduced; setae on terminal joint of palps 'faintly feathered'. The maxilla is figured as having a small series of short setae (presumably filtratory) restricted, as in *Phreatoicoides*, to the proximal part of the inner endite; a gap separates these from an apical series of long setae. In the maxilliped, the brush setae are figured as passing to the apex of the endite. The gnathopod is massive and is unusual in that the dactyl is figured as distinctly shorter than the palm; both the basis and ischium are unusual in shape, being short, as wide as long. Peraeopods slender, basis scarcely expanded.

The pleuron of the fifth pleon segment is shown as fringed with setules, that of the sixth fringed with six simple spines of varying stoutness. Posterior to the insertion of the uropod, the telsonic pleuron bears one or two spines and several setae.

The suture between sixth segment and telson is indicated apparently by a very short and wholly unarmed ridge, but possibly there is present a line of spinules as in *Eophreatoicus*.

*Size.* Male 15.5 mm.

*Colour.* Creamy white in alcohol

*Occurrence.* Associated with *Engaeus cunicularius*, in burrows in the earthen dam of a mine 'near Zeehan, West Tasmania' (1901).

Three attempts have been made by the writer, and another by a student in the Department, to rediscover this species. All have been unsuccessful. The foregoing account has been based, therefore, on the account given by Sayce.

### *Phreatoicoides* Sayce

Body linear, sub-cylindrical. Head long and shallow, produced well in advance of mandible, anterior border slightly emarginate, minute sub-ocular incisure, well-marked cervical groove near posterior margin, mouth parts forwardly placed, disclosing ventro-lateral part of head, posterior process not discernible; eyes wanting; terga of peraeon segments shallow, not concealing ventro-lateral part of segment; first peraeon segment long and free from head, produced very little forwardly onto the head, sternites produced into ventral median prominences, gnathopod with coxa small and set well back behind head; pleon very short and but slightly laterally compressed, pleura practically wanting, wholly exposing the pleopods which are without epipodites. Tailpiece large and truncate, wider than the rest of the body and attached by a narrow joint. Antennule almost filiform; antenna very long; right mandible with vestigial lacinia mobilis, maxillula with but three setospines on inner endite. Gnathopods of breeding male very large, the palm defined by prominent tooth; fourth peraeopod little sexually modified; uropod with short stout peduncle and styliform rami.

*Genotype.* *Phreatoicoides gracilis* Sayce.

### *Phreatoicoides gracilis* Sayce

(Fig. 31)

Sayce, 1900, p. 122, pl. 10-12 (*Ph. gracilis*).

Sheppard, 1927, p. 120 (*Ph. gracilis*).

Sayce's figure suggests that the body is rather more setose than in either of the other two species, from both of which it differs, also, in the depth and shortness of head, the proportions of the first peraeon segment, the length of the seventh segment and in the proportions of pleon segments and tailpiece.

In this species, the head, as compared with peraeon, is not particularly deep, a sub-ocular incisure can be made out, there is a mere indication of a cervical groove, the first peraeon segment is the shortest, but, even so, is little shorter than the head, while both the second and third segments are distinctly longer than the head. In the male of both *longicollis* and *wadhami*, the first segment is longest and is more than twice the length of the seventh which, in Sayce's figure of *gracilis* (l.c., pl. 10) is shown as *longer than* the first. In the pleon, the fifth segment, too, is rather shorter, but the tailpiece relatively longer; the entire pleon (as compared with the cephalo-peraeon) attains its greatest degree of reduction in this species.

Of differences in the appendages, the following should be noted. Antennules and antennae are both rather more setose than in *longicollis*. The fringe of setae on the ventral border of the labrum is continuous. Of the mandibles, Sayce has stated (1900, p. 129) that they 'differ in no essential respect from *P. australis* and *P. terricola*'. Actually these two species differ widely in this appendage, *Phreatoicopsis terricola* showing a well-developed lacinia mobilis on the right mandible, whereas in *australis* and its congeners the structure has been wholly lost.

In all three species of *Phreatoicoides*, the right lacinia is present but greatly reduced. In *P. gracilis*, this structure appears as a slender two-pronged fork and lacks the inner denticulation seen in *longicollis*; in the palps the proportions of the joints, as recorded by Sayce, differ from those of *longicollis*; in the left mandible there are said to be four teeth on both cutting edges, in the Tasmanian species there are but three on the lacinia.

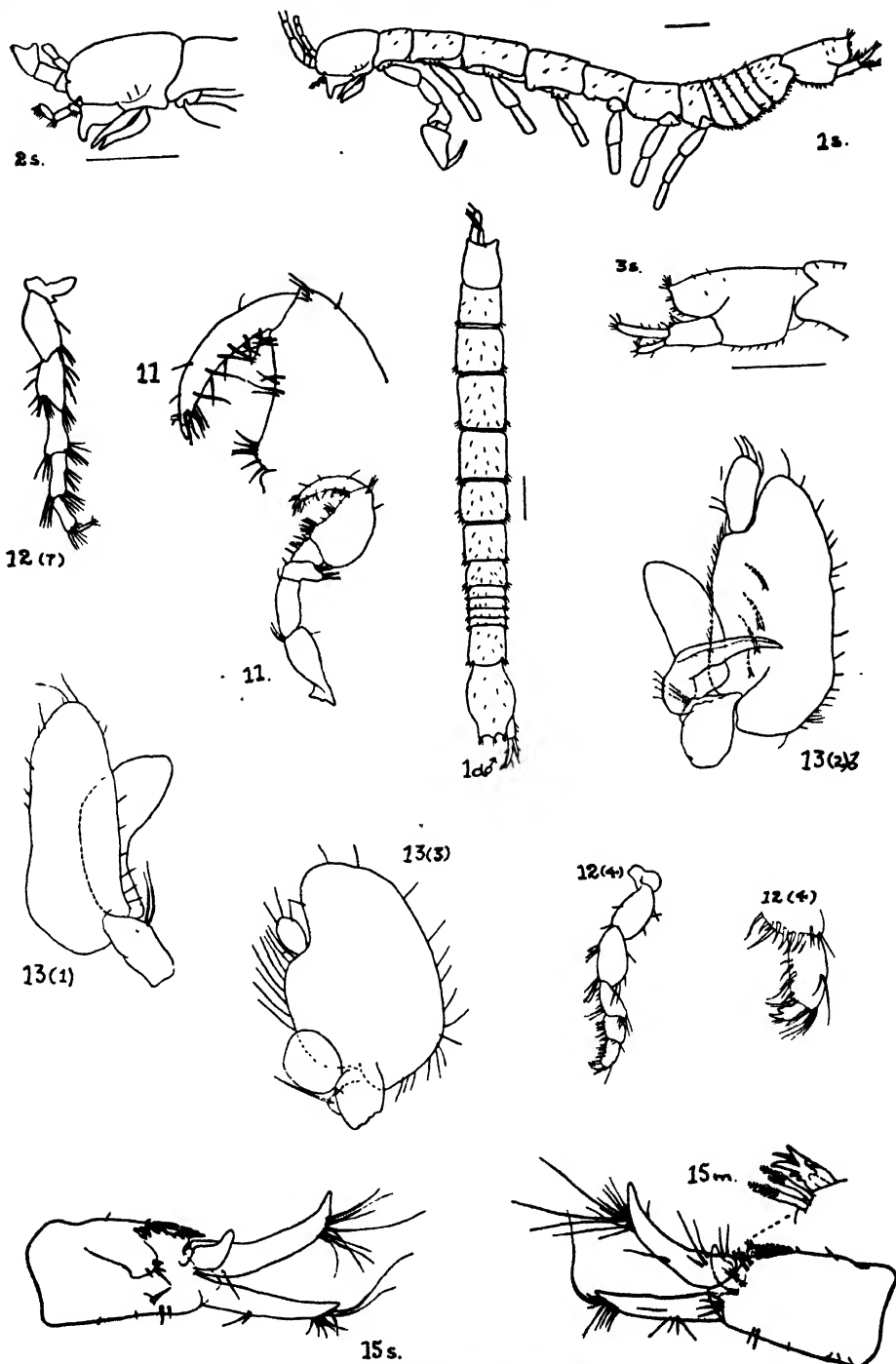
In the *maxillula*, the occurrence of three setospines on the apex of inner endite is apparently constant for the genus, but in *gracilis* the apex is much less oblique; the two simple spines sub-terminal to the setospines are variable; on the outer endite, Sayce records eight or nine spines in *gracilis*; in *longicollis* there are eleven or twelve.

So far as may be judged from Sayce's figure (1900, pl. 12, fig. 7), there is no important difference in the maxilla, although the gap found, in the proximal endite, between proximal and distal setae seems to be less evident in *gracilis*.

The *maxillipeds*, according to Sayce, 'are almost identical' with those of *australis*; they are apparently somewhat variable, for in the single specimen which has been available for examination the condition differs in setosity, etc., from that described by Sayce. It may be said to resemble that of *australis* only in so far as the maxillipeds of this sub-order are all superficially much alike. The coxa is not particularly short; the epipodite long, oval in shape and without fringing setae—the basis is about twice as long as wide; on the endite the long 'brush' setae fringing its dorsal edge are few in number and there is a gradual transition into the condition of the apical setae. On the dactyl there is a fringe of setae on the outer (lateral) border, almost as close as that upon the mesial.

The hand of the *gnathopod* in the male has been described by Sayce as occurring in two conditions 'normal' and 'hymeneal'. The normal condition is said to be similar to that of the female; the hymeneal Sayce found limited to males from 9 mm. to 12 mm. in length, the 'normal' condition occurring in larger specimens (up to 17 mm.). As specimens were said to reach 20 mm., it may be assumed that the largest specimens were female, although a female with brood-pouch is recorded as measuring 12 mm. It seems possible that there is here a protandrous hermaphroditism and that the larger specimens were undergoing a sex change. In the one specimen (male, 10 mm.) examined (fig. 31, 11) the condition of the hand is apparently intermediate between the hymeneal and the normal. There is some variation, also, in details of setation, shape, and proportion of joints. In *P. longicollis*, the propod is much stouter relatively, although the species does not attain to so considerable a size and the shape of the joint is reminiscent of that of *Phreatoicopsis terricola*; a likeness which is still more evident in *P. wadhamsi*.

*Peraeopods*. The fourth peraeopod (fig. 31, 12(4)) is not sub-chelate and the dactyl is very short, but the development of the spines, etc., suggests that the terminal three joints may be capable of a slight prehensility. Sayce's figure (l.c., pl. 12, fig. 11) of the third peraeopod gives the same impression. The seventh

FIG. 31.--*Phreatoicoides gracilis* Sayce.

peraeopod (fig. 31, 12(7)) is distinctly longer than those preceding; the joints from basis to propod show a slight progressive increase in length; the dactyl is relatively long.

**The pleopods.** In the first (fig. 31, 13(1)) of the series, the lamellae are long, oval in shape, the endopodite not greatly reduced, the exopodite with a sparse fringe of simple setae in its distal half. The sympodite is long and bears several long entangling setae. In the hinder appendages there is a marked decrease in the size of the endopodite as well as in the distal lobe of the exopodite. Scattered fringing setae may occur around the whole border of that lamella, but even the second, in the specimen examined, is much less setose than that figured by Sayce (l.c., pl. 12, fig. 13). It is of interest that, in the second pleopod (fig. 31, 13(2)) of this 10 mm. male specimen, the penial stylet is more strongly developed than in the large male (17 mm.) figured by Sayce, which may perhaps lend support to the suggestion that the species may be hermaphrodite and protandrous, the stylet undergoing reduction in size in later ecdyses, that is, with increasing age. It is in this specimen that the marked likeness of this penial stylet to that of *P. terricola* and *H. intrusor* is so noticeable; it is definitely of the Amphisopine type rather than the Phreatoicine. In all of the pleopods, the lamellae may be greatly narrowed proximally to appear stalked—a condition that occurs variably developed in many subterranean forms.

**Uropods (fig. 31, 15).** The peduncle is short and stout, and comparatively bare of setae. Neither inner nor outer dorsal borders are raised, but distally, near to the middle of the dorsal surface, the peduncle is produced into a well-marked spine, as in both of the other species of *Phreatocoides*. Rather surprisingly, this does not appear in Sayce's figure (l.c., pl. 12, fig. 14), nor is it mentioned in his description, and, although it is less developed than in *longicollis* or *wadhamsi*, it is, nevertheless, quite a prominent feature. From a point a little proximal and mesial to this process, there arises a series of spinules which become increasingly multifid (fig. 31, 15m) dorsi-ventrally, along the edge of peduncle, internal to the inner ramus. Beneath the rami, these are represented by minute toothed spines. The rami are styliform, sub-equal, and the inner rather longer than the peduncle. Both have abruptly sharpened apices, set with a ventral tuft of setae, some quite long.

**Occurrence.** So far as can be ascertained, this species has been taken only once, when Sayce found it in a small tributary of the Narracan River running through a steep, virgin fern gully. This was described in 1899 as being almost impenetrably dense. Thirty years later, in the hope of obtaining fresh material of *P. gracilis* for comparison with the newly-found *P. longicollis*, a visit was made to Thorpdale, only to find the whole country rolling down-land with scarcely a tree in sight. After prolonged searching, there was found what seemed to be the shrunken creek, and embedded in its bank, the remains of the trunk of a solitary and almost wholly decayed tree-fern; a few blind Amphipods were collected but there was not trace of Phreatoicids. Traced to its source, the creek was found to issue from a very steep slope near the summit of the hill. A little on the far side of the hill top, there was a large shallow pool which, the writer was informed, could be drained suddenly by thrusting a long pole into its floor, when it would empty by the creek on the opposite side of the hill. It appears probable that there is some considerable subterranean hollow beneath the lake bed, and here, perhaps, *P. gracilis* may still persist. A wide search over the neighbourhood failed to discover any other likely habitat. It had thus, probably, as restricted a distribution as *Hyperoedesis*.

*Phreatoicoides longicollis*, sp. n.

(Figs 32, 33)

Body slender, vermiform, with few short, scattered setae. Pleura of pleon segments not produced, inferior margin of the fifth fringed with a few minute spinules. The total length of pleo-telson about two-fifths that of cephalo-peraeon. Fifth pleon segment distinctly longer than combined length of the four preceding segments. Tailpiece very large, forming more than half of the total length of the pleo-telson, its hinder border shallowly emarginate.

Antennule considerably shorter than peduncle of antenna, with nine or ten joints, peduncle not marked off from flagellum, terminal joints not swollen. Antenna more than two-thirds of the length of the body; peduncle stout, fifth joint longer than the fourth but only about two-thirds of the combined length of second, third, and fourth. Right mandible with vestige of lacinia mobilis. The endite of the maxillula obliquely truncate, bearing three setospines terminally and sub-apically; extremity of outer endite truncate and armed with eleven or twelve spines. Legs slender, seventh pair very long, and with thin expanded basis. Peduncle of uropods stout, reaching end of tailpiece, rami as long as peduncle. Dorsally to the base of the rami, there is a stout spine, backwardly produced, nearly half as long as the outer ramus.

*Colour.* In life, translucent white, with pale yellow patches on head, showing through transparent chitin. In spirit, becoming creamy white.

*Length.* Longest male 13 mm.; female 9.5 mm.

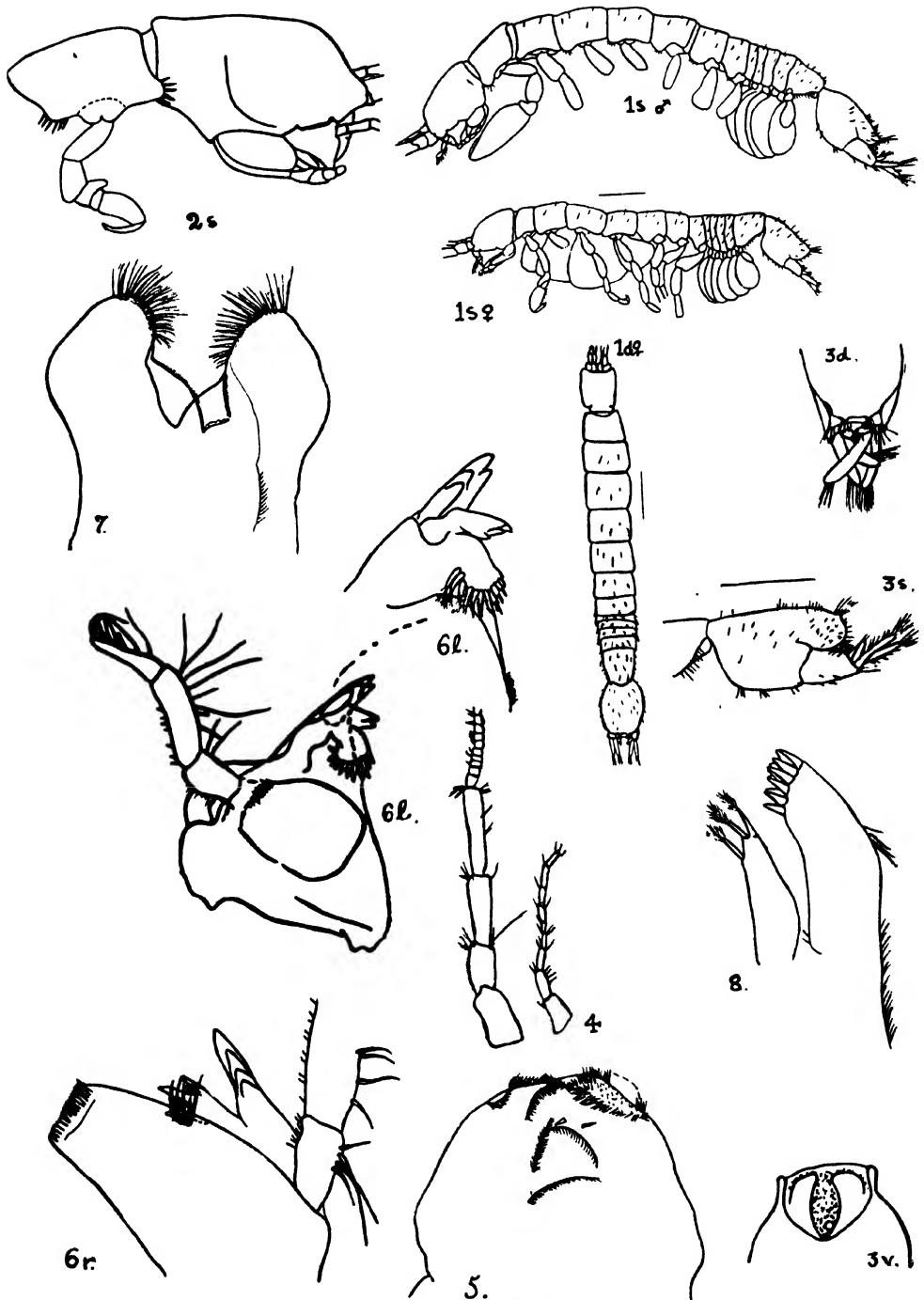
*Habitat.* Under small logs in swampy country, near Queenstown in Western Tasmania (February, 1928 and 1929) and on the slope of Mt. Heemskirk, near Zeehan (February, 1929).

Co-types lodged in the Tasmanian Museum.

The following description was based originally on an examination of the one large male and upon dissections of a smaller male (10 mm.) and a mature female (9 mm.); subsequently, many other specimens have been examined.

The *body* is sub-cylindrical, without wrinkles and but sparsely setose, the setae being most evident on the dorsal surface of the tailpiece. In the male, the length is rather more than ten times the greatest width of the peraeon; in the female only about eight times.

The *head*, without trace of eyes, has, in the male, a length approximately equal to its greatest depth and once-and-a-half the length of the first (or twice that of the second) peraeon segment, whereas in the female, the first peraeon segment is so much shorter than the head is about twice the length of that segment. The anterior border of the head is shallowly emarginate; from here, it rises in a high rounded forehead resembling that of *Hypsimetopus*, but behind, the head contracts markedly, particularly in large males, giving the appearance of a 'neck' and recalling the condition seen in some Anthurids and Caprellids. A peculiar feature, particularly noticeable in the larger males of this species is the forward extension of the head to project in front of the labrum, the sub-ocular incisure appearing on this anterior extension as a small notch. A sub-ocular segment is not indicated, but behind the labrum on the ventro-lateral border a second and larger notch lodges the fulcral process of the mandible. The ventro-lateral border of the head is sinuous, nearly horizontal and is not produced behind the mandible into a posterior process. From the ventral margin near its posterior end, a well-marked groove runs upward obliquely, not extending to the dorsal middle line and thus marking off only incompletely from the head a wide posterior region sub-triangular in shape; this is obviously the cervical groove of other Phreatoicoids.

FIG. 32.—*Phreatoicoides longicollis*, sp. n.



*Peraeon*. In the male, the first peraeon (second thoracic) segment is free and is remarkably long, as long as the anterior region of the head (i.e., the part in front of the cervical groove). This is longer than either of the two next succeeding segments which are sub-equal and are followed by three others, also sub-equal but slightly shorter. The seventh peraeon segment is the shortest, having a length of little more than two-fifths of that of the more anterior segments. The sixth and seventh combined have a length equal to that of the first peraeon segment. Similar proportions are found elsewhere only in *Hypsimitopus* but seem to be usual in the Anthuridae. The inferior margin of the peraeon segments appears to be nearly straight. In the female, the first peraeon segment is shorter than the second and the third is the longest. Upon the ventral surface of the thoracic region, the body is produced in the mid-ventral line into a number of prominences, particularly noticeable posteriorly. Sayce has figured somewhat similar structures in *P. gracilis* (1900, pl. X, fig. 1), but they are apparently more strongly developed in the Tasmanian species.

The *pleon* is divided into the usual six segments, but the first four are sub-equal and unusually short, their combined length being about that of the third peraeon segment. They are, indeed, shorter than in any other Phreatoicid, here again recalling the condition of *Apseudidae* and some *Anthuridae*. The fifth pleon segment is, however, rather well developed, having a length almost equal to that of the second peraeon segment. The sixth segment, too, is large, and with the telson makes a massive tailpiece longer than the whole of the rest of the pleon, and having a length equal to, or even slightly exceeding, that of the head. It is nearly once-and-a-half as wide as the rest of the body. Upon the first to fourth pleon segments, the pleura are scarcely developed, thus completely exposing the pleopods. There is, however, a small pleural development upon the fifth and sixth segments, but not sufficient to hide the junction of these two segments, in which region the body is quite markedly constricted. Such an arrangement permits, as Sayce pointed out in his description of *P. gracilis* (1900, p. 127) of a deep ventral flexion of the tailpiece. As noted below, movement is effected by a quick wriggling action of the whole body, but unfortunately no observation was made to determine whether any abrupt backward movement may be effected by the tailpiece. The postero-ventral margin of the pleuron of the fifth segment is fringed with short spinulose setae. Of fringing setae upon the ventral border of the sixth segment, there are none or very few in the male, rather more in the female, but posterior to the insertion of the uropods the ventral margin of the telsonic pleuron is furnished with a number of setae.

Seen from above, the telson appears as a very slightly emarginate body, the actual posterior border of the last tergum being slightly concave, but behind this, the almost transverse end of the body projects slightly. Laterally, the telson is continued into small pleura giving, to a section through the region, a short wide U-shape, a condition closely similar to that described by Sayce in *P. gracilis*.

The *antennule* (fig. 32, 4) is elongate and slender, reaching to the last joint of the peduncle of the second antenna (fig. 32, 4). It consists of nine joints, of which the proximal three may be considered as constituting the peduncle, though there is little to mark them off from the terminal joints which make up the flagellum. In their proportions, these flagellar joints differ somewhat from those of *P. gracilis*. The first and second are short and sub-equal, the third and fourth sub-equal but rather longer, the fifth is long and slender and the last a mere knob. It bears an 'olfactory cylinder' and a tuft of setae, the penultimate joint bearing one or two of these 'cylinders'.

The *antenna* is very long, nearly three-quarters of the length of the body. There are the usual five joints in the peduncle, of which the fifth is relatively much longer than in *P. gracilis* and bears but a few terminal setae. The number of joints in the flagellum is about twenty-five, but many of the articles appear to have been about to undergo division, perhaps in anticipation of the next ecdysis. The first and second are short, the third and fourth still shorter and they continue short till the ninth. The tenth is longer and appears to include two and they so continue, increasing in length, to the seventeenth. In the eighteenth, three articles are indicated. To the twenty-fourth, there are two pieces, while the last is but a simple piece. Each joint has a distal circlet of setae but the components are without setae; if these really represented separate articles, the flagellum would have as many as forty-six joints.

*Labrum*. This is, as usual, markedly asymmetrical; the ventral border is very sparsely setose (fig. 32, 5).

The *mandibles* are short and stout. In the left mandible (fig. 32, 6l) the primary dentate edge has four strong teeth, the lacinia is well-developed and has three dark, heavily chitinated teeth; spine row broad with numerous denticulate spines but three or four of the more distal are setospines; the molar short with rounded sub-quadrangular grinding surface. An acetabular process is developed, but the fulcral process was not seen. The right mandible (fig. 32, 6r) differs noticeably in the great reduction of the lacinia, which is little more than a stout, two-pronged spike, scarcely separated from the spine row. Occasionally, a minute third tooth appears as a small, bent projection between the two longer teeth. The principal cutting edge has four teeth. The right molar is much longer and more slender than the left.

The *labium* (fig. 32, 7) has inner lobes which are fringed only with short, fine setae; the large outer lobes are setose only apically and mesially.

The *maxillula* (fig. 32, 8) shows almost the maximum degree of reduction in the proximal endite, on which there are never more than three setospines, while one or usually both of the two simple spines so generally present to Phreatoicidae are absent. The endite is narrow and may even taper to a point, the setospines almost mesial in position. The outer endite has the shape characteristic of *Synamphisopus*, being sharply bent at about its mid-point and armed apically with about a dozen stout spines. The sub-terminal plumose setae on the face of the endite are also missing.

The *maxilla* (fig. 33, 9), too, has undergone considerable reduction. The basal part of the proximal endite is variable but usually projects slightly and carried a short fringe of filter setae backed by four or five<sup>(1)</sup> stout setae from which the pectinations normally developed are practically wanting. The distal part of the endite is long relatively, much of its mesial border free from setae, but densely armed apically with simple and biting setae. Of the two distal endites, the inner may be quite narrow and short, the outer much wider, or they may be of almost equal length, each carrying a mixed series of denticulate and simple setae.

In the *maxilliped* (fig. 33, 10ml) the features to be noted are the relatively large sub-ovate epipodite produced to a blunt point much as in *Hypsometopus*, setose only near its mesial border, the short basis with its endite armed mesially with a few (six or seven) brush setae and an apical series of short plumose setae; the palp rather short, with carpus mesially expanded, propod almost circular, the dactyl flattened and narrow, with few setae, practically all springing from its mesial border. One or two coupling hooks may be present. In the female, the

(<sup>1</sup>) Seven on the left appendage, and nine on the right, in one female.

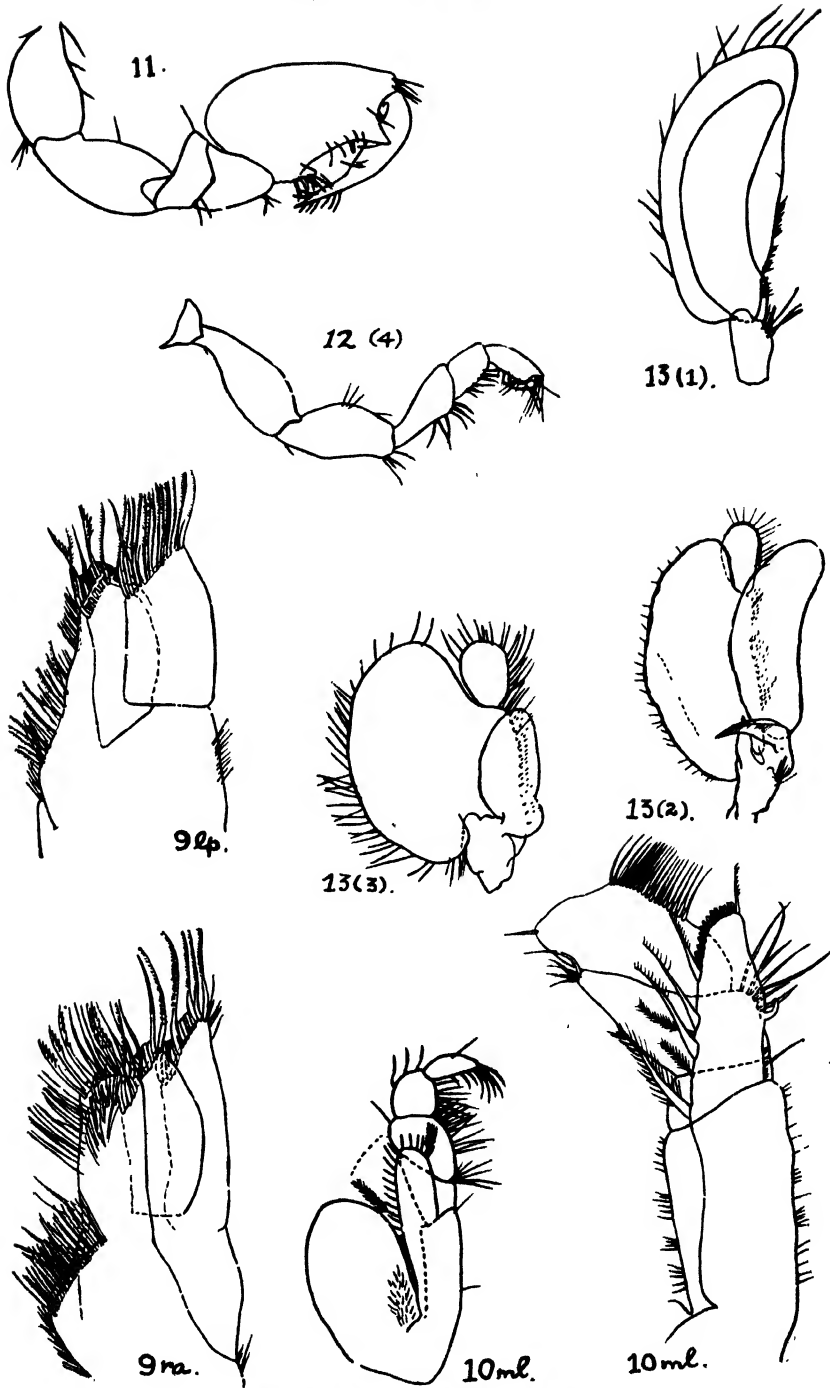


FIG. 88.—*Phreatoicoides longicollis*, sp. n.

coxal lobe is large. It is carried vertically, projecting obliquely into the brood-pouch, the anterior lobe of the first oostegite lying as usual externally to it and sheathing the coxa of the maxilliped. The free lateral border of the coxal lobe bears mesially some half-dozen short curved setae and, more laterally, as many but much longer and very flexible setae.

*Gnathopod.* Male (fig. 33, 11), ischium as long as basis, merus produced antero-distally, the propod very stout, with anterior border convex, the palm produced into a great spine proximally and a second even longer, at the distal end of the palm which, between these spines, is slightly concave; dactyl is strong near its base but narrows abruptly near its tip; it is almost as long as the posterior border of the propod, its apex coming to rest against the setose posterior surface of the proximal spine. In the female, the proportions of the joints are much the same, except for propod and dactyl, both of which are but moderately developed.

*Peraeopods.* The sexual modification of the male fourth peraeopod (fig. 33, 12(4)) is very slight, for, although this appendage is sub-chelate, the propod hardly differs from that of preceding appendages.

The *pleopods* have undergone very considerable reduction. The first (fig. 33, 13(1)) has a fairly long sympodite carrying four or five entangling setae on its mesial border; the exopodite is slightly longer and nearly twice the width of the endopodite and bears a few fringing setae on the convex lateral border and also a few simple setae proximally on the mesial edge. The endopodite is quite bare of setae. In the second pleopod (fig. 33, 13(2)) there is a small mesial coupling lobe on sympodite with about seven long setae; the exopodite resembles that of the first appendage, except that there is a short distal lobe and that the mesial setae are less abundant; the endopodite has a rounded basal lobe from which springs the outer respiratory lamella, and mesially, in the male, a very stout penial stylet. This tapers strongly to a narrow apex, is without terminal setae, but bears a few (four or five) marginal spinules. The succeeding pleopods bear, on the sympodite, pronounced mesial coupling lobes, but are without epipodites. In the two hindermost the exopodites are noticeably shorter and wider, the endopodites become narrower but reach always to the base of the distal lobe of the exopodites (fig. 33, 13(3)). On the latter, plumose setae are generally wanting, but strong simple setae line the short mesial border of the proximal lobe and rather longer setae fringe the outer border.

On the *tailpiece* (fig. 32, 3s) a tuft of long terminal setae arises from the flattened surface *beneath* the transverse posterior border; the telsonic pleura are convex, somewhat produced. Their surface is markedly setose. A short suture is continued forwardly from the dorsal border of the uropod but bears no spines or setae; the ventro-lateral border of the sixth pleon segment anterior to the uropods has two or three tufts of short setae.

The *uropods* (fig. 32, 3d) are styliform; the peduncle is short and deep, extending scarcely behind the posterior end of the body; the rami long and sub-equal, the outer a little the shorter, but as long as the peduncle, the whole appendage bearing many long setae. From the mid-dorsal border, between the rami, rises a short stout spine.

*Occurrence.* These Phreatoicids were first taken in open 'button-grass' country, by the side of a narrow-gauge railway about three miles from Queenstown. This one-time ore line now serves the electric power station below Lake Margaret, and even in midsummer, this patch of country is usually extremely wet, water lying to the depth of an inch or so over considerable areas and slowly draining

into a sphagnum-choked ditch by the side of the line.<sup>(1)</sup> Across this wet country an old 'corduroy track' composed of stout sticks and stems of saplings, many well advanced in decay, led away in a north-westerly direction towards Zeehan.<sup>(2)</sup> These poles were partially embedded in firm mud and for the most part under water, there being a much more evident flow along this trail. It was on the under surface of these partially-decayed logs that the specimens were obtained. On disturbing the logs, the isopods at once dropped off, travelling quickly in the trickling muddied water by an active wriggling movement of the whole body. By accident or design, many reached one or another of the numerous gaping mouths of burrows (probably those of an *Engaeus*) down which they passed at once from sight. A single log commonly harboured several, but of these it was rare to secure more than one or two, their successful escape being the more surprising in view of their blind condition and inability to swim in the more usual direct Isopod fashion. An attempt to dig them out proved quite unsuccessful, the mud at a foot below the surface being practically liquid. It is of interest to note that all of the specimens secured were taken in the early forenoon (February 6th). None were seen on the occasion of the first search at this spot in the late afternoon of the previous day, nor again at a somewhat early hour in the afternoon of February 6th. An explanation which suggests itself is that this Phreatoid (like *Hypsimetopus*) normally shares the burrows of *Engaeus* from which it emerges periodically to feed on the decaying surface of these logs. On the other hand, the association may be a purely accidental one and their escape into these holes may have been due to in-sinking currents which swept them into safety. Both the *Engaeus* and these semi-terrestrial Phreatoids are obviously restricted to localities almost permanently waterlogged, where they live practically at, or very near, the surface but it may be the case in *Hypsimetopus*, as in that of *Phreatoicoidea gracilis*, that life above ground under decaying wood or within its crevices is the normal condition and that only when forced underground by conditions of exceptional dryness, or when disturbed, do these creatures take refuge within the 'land crab' burrows. It seems likely that the association is a wholly casual one.

The inclusion of these notes seems warranted in the interest of those who may engage in the search for such cryptozoic forms. The country-side in which they occur is one in which precise landmarks are not readily available and for the lack of guidance, days may be wasted on fruitless searching. The presence of the writer in this particular district was due, amongst other things, to an attempt to rediscover *Hypsimetopus*. This Phreatoid was found, apparently quite accidentally, more than forty years ago and three specimens were sent (by whom it has proved no longer possible to discover) to Professor Haswell and, subsequently, described by Sayce (1902). The locality is given as 'Near Zeehan, Tasmania, in burrows of *Engaeus cunicularis*'. During the summers of 1928 and 1929, and again in 1939, several days were spent in and around Zeehan in an entirely fruitless search for this species (*H. intrusor*)<sup>(1)</sup> and, at the present time, one male specimen in the National Museum, Melbourne, apparently constitutes the entire available material.

As regards *Phreatoicoidea longicollis*, eighteen specimens were secured, on the first occasion, in an hour's collecting. Of these, four were males, ranging in length, when preserved, from 6 mm. to 11.5 mm. All of these showed the very characteristic hand quite well developed, although, in two examples, one of the gnathopods

(1) It was in this patch of sphagnum that the Syncarid, *Micraspidius calmani*, was first discovered.

(2) In 1939, the occasion of the last visit, it was found that conditions were largely disturbed by the cutting of the new road from Queenstown to Zeehan.

(3) A curious coincidence is the close external likeness of *longicollis* to *Hypsimetopus*.

had recently been lost. In one of these, a very small limb had regenerated and upon this, the 'hand' was still in a quite immature state. Eight others were visibly female, six being provided with a fully-grown, but empty, brood-pouch, the other two having the oostegites as narrow firm lamellae adpressed to the ventral body wall. The largest female obtained at that time reached a length of 8.5 mm.

In 1929, the collecting area was extended and both *Micraspides* and *Phreatoicoides longicollis* were again taken, once in boggy country thirteen miles (by road) south-east of Queenstown and later, a dozen miles or so to the west of Zeehan, on the southern slopes of Mt. Heemskirk. Some of the *Phreatoicoides* reached a rather greater length, but no ovigerous females were taken. In succeeding years, other attempts were made fruitlessly by a student from the University of W.A. to rediscover these species, and in 1939 the writer revisited the original localities and many new ones, but with no success. It seems evident that only under the normally very wet conditions can such collecting be attempted with any hope of success and on every occasion *Hypsimetopus* has eluded us.

For *Phreatoicoides gracilis*, Sayce (1900, p. 125) found that the ratio of pleo-telson to cephalo-peraeon was but 36 to 100, and these proportions were stated to be invariable (l.c., p. 137). It is to be assumed that Sayce's measurements were made upon a number of fully-grown specimens, but there is no statement whether or not this ratio measurement was obtained from living (or freshly-killed) specimens. If that were the case, the proportions of these two body regions would be almost identical with those obtaining in living *P. longicollis*. A considerable shrinkage in length takes place during preservation in spirit, sometimes resulting in the almost complete obliteration of the intersegmental regions. In life, these are quite notable, particularly in the peraeon, so that measurements made upon the living animal would show an even greater disproportion between the cephalo-peraeon and the pleo-telson regions. An examination of the smaller specimens of *P. longicollis* suggests that this disproportion increases with the increase in total length. Thus, in a male of 8.5 mm., the ratio of pleo-telson to cephalo-peraeon is approximately 43 to 100, whereas in the largest specimen this ratio has fallen to barely 40 to 100. Miss Sheppard (1927, p. 84) notes that in an example of *P. gracilis* which she examined, the ratio was 46 to 100. Her specimen was presumably one which had been in preserving fluid and for many years, and which had undergone the maximum shrinkage. It is possible, moreover, that this specimen was not fully-grown and had not attained, therefore, mature proportions.

As Chilton (1916) has pointed out, too much reliance must not be placed upon such measurements, as these may, perhaps, vary with age, and be different in the two sexes. Moreover, these measurements are by no means easy to determine with accuracy nor may one too confidently base comparisons upon the strength of measurements made from published drawings, since these may easily prove misleading. But there can be no warrant for questioning the accuracy of Sayce's measurements in the case of *P. gracilis*, in view of his statements above quoted, and it is thus of considerable interest to find his figures agreeing so very closely with those obtained from the full-grown specimen of *P. longicollis*.

The most striking feature in the male of all these species of *Phreatoicoides* is the marked reduction in length of the first four pleon segments and a narrowing of the anterior five, associated with an increase in width in the tailpiece. This is particularly noticeable in *P. longicollis*, although the fifth segment is relatively rather large; it is seen also in the immature female. It is evidently a development

peculiar to this genus and, perhaps, to *Hypsimetopus*; there is just a hint of it in *Hyperoedesipus*. There is no suggestion of such a widening in the tailpiece in the vermiform New Zealand species.

*Phreatoicoides wadhami*, sp. n.

(Fig. 34)

Body (fig. 34, 1) slender, vermiform, almost free from setae; the head much longer than deep but less than the combined length of the first and second peraeon segments, with strong ridge running around the anterior region and continued along the ventro-lateral border; cervical groove only faintly indicated; first to fourth peraeon segments sub-equal, fifth, sixth, and seventh progressively shorter and deeper; pleon with pleura scarcely developed, first to fourth segments short, with few fringing setules, fifth segment as long as the combined length of the four preceding segments; pleuron restricted to the anterior half of the ventral border, with few setules; tailpiece rather less than half of pleo-telson.

*Antennule* (fig. 34, 4) shorter than peduncle of antenna with ten or eleven joints; joints of peduncle sub-equal, but first joint expanded laterally, flagellum almost filiform, joints elongate, terminal joints not swollen. *Antenna* (fig. 34, 4) very long, reaching to fourth pleon segment, flagellum with sixty-six joints. *Right mandible* (fig. 34, 6r) with lacinia mobilis reduced to a single spike.<sup>(1)</sup> *Maxillula* (fig. 34, 8) with setospines along inner border of proximal endite. *Gnathopod* with very strong hand, dactyl (fig. 34, 11l) stout, carrying numerous strong setae. Fourth *peraeopod* subchelate.

*Pleopods*. First pleopod (fig. 34, 13(1)) practically the entire border setose; a few plumose setae latero-distally; penial stylet on second pleopod slender, endopodites long on all but the fifth; distal lobe of exopodite not reduced.

*Uropods* (fig. 34, 15) stout, styliform, the distal process of peduncle projecting above and between the rami, a row of spinules running obliquely from the middle of the dorsal surface to the outer distal angle; rami rod-like, truncated apically to end in a sharp point, the inner bearing a terminal tuft of long setae.

*Colour*. Whitish, translucent in life.

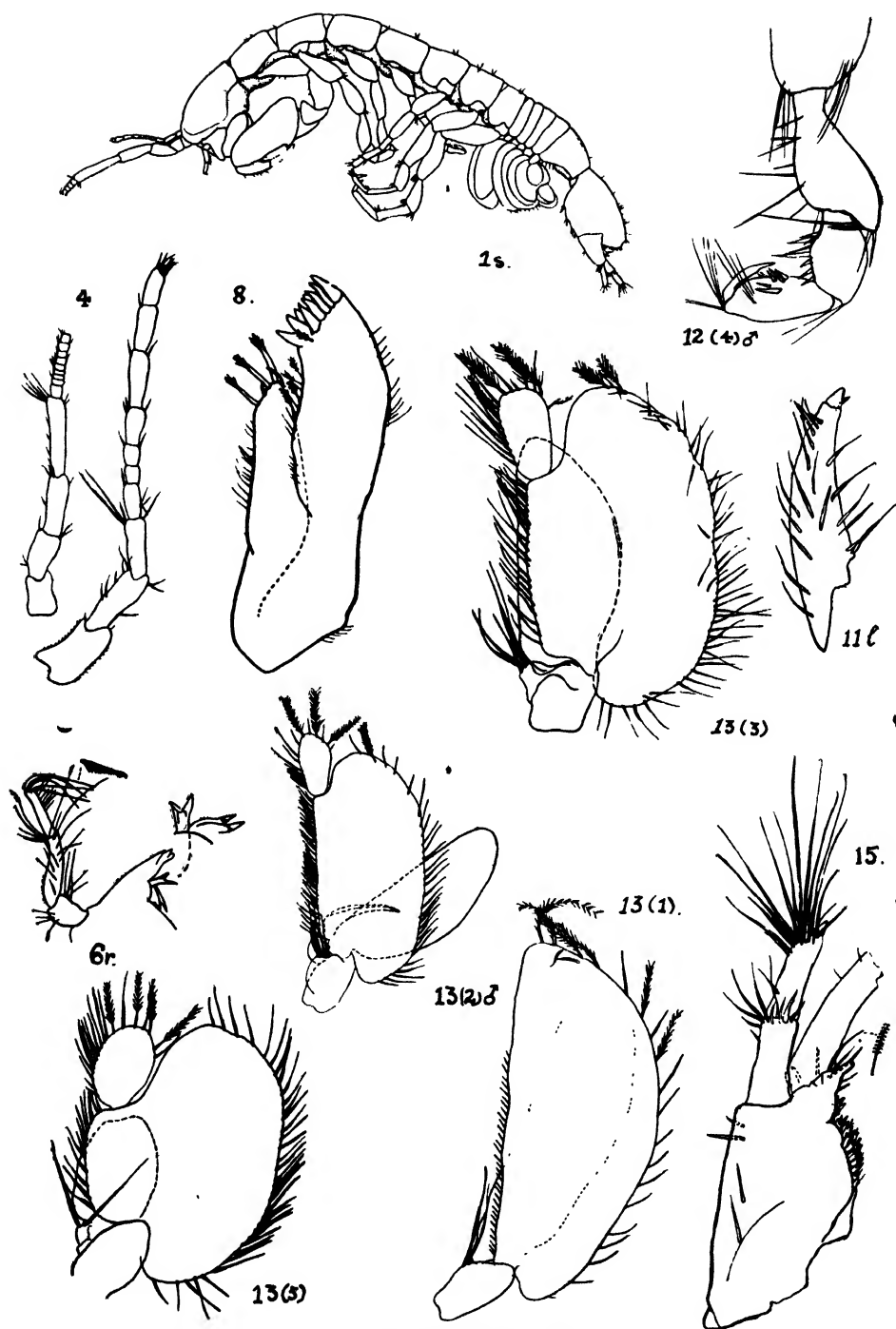
*Size*. 9 mm. male.

*Locality*. Beechforest—Otway Mts. (Victoria).

The description is unfortunately incomplete, only a single male, somewhat damaged and almost certainly immature, being available for examination. This was found in sphagnum which had been used as packing for a number of *Phreatoicopsis terricola*, sent alive by air-mail in the early summer of 1937. The same moss contained one example of *Trichoniscus* sp. as well as a number of planaria and *Geonemertes* sp. In January, 1939, an attempt was made to obtain further specimens, but proved fruitless.

The specific name proposed is in compliment to Professor Wadham, by whom the material was collected.

<sup>(1)</sup> Which may be bifid.

FIG. 34.—*Phreatoicoides wadhami*, sp. n.





## On some new Hadrotarsidae (Araneae) with Notes on their Internal Anatomy

By

V. V. HICKMAN

(Read 25th November, 1942)

### PLATES I-V

The family Hadrotarsidae contains only two species, namely, *Hadrotarsus barbirussa* Thorell from Yule Island, New Guinea, and *Gmogala scarabaea* Keyserling from Sydney, New South Wales. Thorell (1881, p. 190) appears to have had only two specimens of *H. barbirussa*, one a male, the other a female. He has given a detailed account of the male, but the female was damaged before he was able to complete the description and therefore very little is known of its characters. Keyserling's account of *Gmogala scarabaea* is based on a female specimen which was later lodged in the British Museum. Pocock (1903, p. 619) re-examined the specimen, and offered some supplementary remarks on the genus. He came to the conclusion that Keyserling's description was 'defective in many points, erroneous in others', and that the two genera, *Hadrotarsus* and *Gmogala*, were identical.

Hadrotarsidae are particularly rare. Rainbow (1902, p. 315) states that there is a single female specimen of *G. scarabaea* in the Australian Museum, Sydney. This appears to be the only Hadrotarsid in any museum in Australia. When Simon wrote his comprehensive work he had no specimen of this family for study and was forced to rely on the descriptions given by Thorell and Keyserling. More recently Petrunkevitch (1933, p. 305) remarked that no specimens of Hadrotarsidae were 'available in any museum in the world for anatomical studies'. It follows, therefore, that our knowledge of this group is very deficient. Some authorities have suggested abandoning the Hadrotarsidae and transferring the genera *Hadrotarsus* and *Gmogala* to other families (see Berland, 1932, p. 359, Crosby, 1934, p. 21, and Gerhard and Kästner, 1938, p. 592).

The present paper deals with three new species which, in my opinion, belong to the genus *Hadrotarsus* and justify the retention of the family Hadrotarsidae. The main features of the internal anatomy of two of the species are described and a new definition of the family is given.

## Order ARANEAE

## Sub-order DIPNEUMONOMORPHAE

## Family HADROTARSIDAE

Genus *Hadrotarsus* Thorell, 1881*Hadrotarsus ornatus*, sp. n.

## Male. Measurements in millimetres:—

Total length	1.5660
Length of cephalothorax	0.4932
Width of cephalothorax	0.6165
Length of abdomen	1.2330
Width of abdomen	1.0412

Leg	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
1	0.3425	0.2055	0.2877	0.1781	0.3151	1.3289
2	0.2740	0.1918	0.2603	0.1644	0.3014	1.1919
3	0.2603	0.2055	0.2466	0.1712	0.2877	1.1713
4	0.3562	0.2603	0.3151	0.2192	0.3425	1.4933
Palp	0.1781	0.1096	0.0685		0.4110	0.7672

*Colour.* Carapace yellowish brown with narrow black lateral margins and a black reticulate pattern behind eyes. Ocular area black anteriorly. Legs yellowish brown becoming darker towards the apex. Chelicerae, palpi, labium, maxillae, and sternum yellowish brown. Dorsal shield of abdomen yellowish brown crossed by four transverse black bands, which are interrupted in the middle. Ventral sclerites yellowish brown.

*Carapace.* Wider than long, somewhat narrowed in front, emarginate behind and with well-rounded sides. Thoracic groove wanting. Radial grooves faintly marked. Head part moderately high. From behind PME the carapace slopes gradually to the posterior margin. Surface smooth, shining and almost glabrous (pl. I, fig. 1).

*Eyes.* Viewed from above the eight eyes are seen to be arranged in two rows. The front row appears slightly recurved. Viewed from in front the anterior row is distinctly procurved, the lateral eyes being nearer the edge of the clypeus than are the median eyes. The posterior row is strongly procurved (pl. I, fig. 2). The eye ratio AME : ALE : PME : PLE = 5 : 5 : 8 (long) : 5. AME are on a small tubercle and are separated from each other by  $\frac{1}{2}$  and from PME by  $\frac{1}{2}$  of their diameter. They are in contact with ALE, which are in contact with PLE. PME are large, reniform, and flat. They are almost contiguous with each other, but separated from PLE by a space equal to the diameter of AME. The width of the eye-group is slightly less than the width of the carapace in the region of the eyes. The quadrangle formed by the median eyes is wider in front than behind in ratio 12 : 9. Its length is greater than its anterior width in ratio 14 : 12. The AME are dark, the other eyes pearly white. The height of the clypeus in front of AME is about  $18/5$  of diameter of AME.

*Chelicerae.* Small, conical, vertical, and without lateral condyles. Their inner edges obliquely diverging, devoid of teeth and scapula, but furnished with a row of three straight setae near the base of the fang. The fangs are moderately long and falcate. They lie transversely and cross each other (pl. I, fig. 3).

*Maxillae.* Triangular, converging in front of labium. Their inner ends pointed and membranous. A serrula consisting of eleven teeth is situated on the antero-lateral margin. The inner margin has a short scopula (pl. I, fig. 4).

*Labium.* Triangular, rounded and membranous in front. Wider than long in ratio 7 : 5. Furnished with three pairs of setae (pl. I, fig. 4).

*Sternum.* Convex, rounded and triangular. Width equal to length. The posterior end truncate. Fourth coxae separated by slightly more than their width. Middle of sternum glabrous, but its sub-marginal region is clothed with a few hairs which point inwards (pl. II, fig. 13).

*Legs.* 4.1.2.3. The first pair of legs with swollen tarsi. The joint between tarsus and metatarsus in both the first and second pairs of legs not constricted (pl. I, figs 5 and 6). Integument is clothed with barbed hairs. These are coarser and more numerous on the tarsi than elsewhere, especially on the ventral surface of the first tarsi. Spines and scopulae are wanting. Each leg has three trichobothria; one on the metatarsus near the apex and two on the tibia, one of which is near the middle, the other near the base. Two tarsal claws situated on a short onychium are present. The prolateral and retrolateral claw of each leg, excepting those of the fourth pair, are pectinate on both promargin and retromargin. The number of teeth and their arrangement differ on the different claws, as is indicated in the following table:—

	Prolateral Claw		Retrolateral Claw	
	Teeth on Promargin	Teeth on Retromargin	Teeth on Promargin	Teeth on Retromargin
Leg 1	12	1	10	1
Leg 2	11	1	9	1
Leg 3	10	1	1	8
Leg 4	8	0	0	8

The pectination of the claws of the first, third, and fourth pairs of legs is shown in pl. I, figs 7, 8, and 9. At least one pair of barbed setae on each tarsus appear to act as spurious claws.

*Palpi.* Moderately long. Cymbium spoon-shaped. Tibia short and saucer-shaped, devoid of apophyses but provided with a single trichobothrium. Patella short. The genital bulb has the form shown in pl. I, fig. 10. It is provided with a long, coiled embolus which makes two complete turns in the basal half of the cymbium and then passes round the retrolateral margin and apex to make a complete turn in the distal half of the cymbium. The tip of the embolus projects slightly on the prolateral side. Parallel with the end of the embolus is a hard, slender, terminal apophysis, which is provided with a few minute teeth on one side (pl. I, fig. 11). Near the tip of this apophysis is a small hook-like projection on the cymbium. Under high magnification the embolus is seen to have a small barb near the tip (pl. I, fig. 12).

*Abdomen.* Ovate, covered dorsally by a hard shield, which has a narrow V-shaped notch in the middle of its anterior margin. On both sides of the notch are a few coarse spine-like setae. The rest of the shield is lightly clothed with fine, short hairs. The front of the abdomen overhangs the carapace. The anterior half of the ventral surface is covered by a large epigastric scute, which extends forward and surrounds the pedicle. The lung covers are incorporated in the scute

and appear as a pair of long oval patches, one on each side. The epigastric furrow lies immediately behind the epigastric scute. The two lung slits are situated in the furrow, one on each side. Behind the furrow is a small median sclerite, on each side of which is a slightly larger lateral sclerite fused to the epigastric scute round the outer end of the lung slit. These two lateral sclerites partly overlap the posterior edge of the epigastric scute, thus hiding part of the epigastric furrow (pl. II, fig. 13). Behind the median and lateral sclerites is a large ventral scute, which covers most of the posterior half of the ventral surface. Near the antero-lateral angles of this scute is a pair of small rounded sclerites, one on each side. Attached to the posterior edge of the ventral scute and immediately in front of the spinnerets is a small median sclerite, on which is situated the single tracheal spiracle. The integument at the sides of the abdomen exhibits a series of three longitudinal folds, two of which are continuous anteriorly above the pedicle and posteriorly above the anus. The two most ventral folds on each side are reinforced with a number of small sclerites which tend to fuse together forming irregular longitudinal bars. Posteriorly, some of the bars unite with the ventral scute and with one another so as to form a hard chitinous ring almost surrounding the spinnerets.

*Spinnerets.* Six. The anterior pair short, conical, and close together. Each consists of a basal segment and a small apical segment. The inner surface of the basal segments thickly chitinized and marked with fine transverse ridges to form what is probably a stridulating organ. The small apical segment is furnished with three long, slender, spinning tubes (pl. II, fig. 14). The middle spinnerets are very small and not visible unless the other spinnerets are parted. Each consists of a single narrow segment provided with one spinning tube (pl. II, fig. 16). The posterior spinnerets are short, conical, and two-segmented. The apical segment is provided with a very wide spinning tube or spigot and two slender tubes (pl. II, fig. 15). A colulus is wanting.

**Female.** Measurements in millimetres:—

Total length	1.8084
Length of cephalothorax	0.5891
Width of cephalothorax	0.6165
Length of abdomen	1.2878
Width of abdomen	1.0459

Leg	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
1	0.3562	0.2192	0.2603	0.1781	0.3014	1.3152
2	0.3425	0.2055	0.2329	0.1781	0.2877	1.2467
3	0.3151	0.2055	0.2329	0.1781	0.2877	1.2193
4	0.3973	0.2603	0.2945	0.2192	0.3425	1.5138
Palp	0.1370	0.0616	0.1233		0.1781	0.5000

The female resembles the male in coloration, markings, and general appearance. Hence only the following features need be described: —

*Eyes.* The eight eyes are arranged as in the male. The width of the eye-group is less than the width of the carapace in the region of the eyes in ratio 20 : 25. Viewed from above, the front row of eyes is almost straight, but viewed from the front it is procurved, the lateral eyes being nearer the edge of the clypeus than are the median eyes. The posterior row is strongly procurved. Ratio of eyes AME : ALE : PME : PLE = 4 : 5 : 7 (long) : 5. AME are slightly smaller than in the male. They are separated from each other by  $\frac{1}{2}$  and from PME by  $\frac{2}{4}$  of their diameter. They are in contact with ALE, which are in contact with

PLE. PME are large, flat, and reniform. They are almost contiguous with each other but separated from PLE by a space equal to the diameter of AME. The median ocular quadrangle is wider in front than behind in ratio 11 : 9. Its length is greater than its anterior width in ratio 15 : 11.

*Labium*. Triangular, rounded in front, wider than long in ratio 9 : 4, provided with seven setae.

*Chelicerae* and *Maxillae*. As in the male.

*Sternum*. Convex, rounded, and triangular. Longer than wide in ratio 28 : 26. Clothed with a few sub-marginal hairs which point inwards. Posterior end truncate. Fourth coxae separated by slightly more than their width.

*Legs*. 4.1.2.3. As in the male, but the tarsal claws show slight differences in the number of teeth. See following table:—

	Proterolateral Claw		Retrolateral Claw	
	Teeth on Promargin	Teeth on Retromargin	Teeth on Promargin	Teeth on Retromargin
Leg 1	12	1	11	1
Leg 2	12	1	9	1
Leg 3	9	1	1	9
Leg 4	8	0	0	8

*Palpi*. Clothed with barbed setae but devoid of spines. One trichobothrium on tibia, elsewhere none. The single tarsal claw has eleven teeth on the promargin and one on the retromargin. The claw is so curved that the row of teeth on the promargin is almost transverse to the long axis of the tarsus, and the claw appears like a minute rake (pl. II, fig. 17).

*Abdomen*. Ovate, and provided with a hard dorsal shield as in the male. The scutes on the ventral surface, however, are somewhat different from those of the male (pl. II, fig. 18). There is a large ring-like sclerite surrounding the base of the pedicle, the ring being wider anteriorly than posteriorly. Behind the ring is a moderately large rectangular median scute occupied by the epigynum. On each side of this median scute, but separated from it, is an elongated pulmonary sclerite protecting the book-lung. The openings of the book-lungs lie, one on each side, between the pulmonary sclerite and a smaller sclerite, which is partly fused to its posterior margin. Behind the epigynum is a small median rectangular sclerite, on each side of which and behind the postero-lateral angle of the pulmonary sclerite are two small lateral sclerites situated one behind the other. The posterior half of the ventral surface is covered by a large ventral scute. Attached to the posterior margin of this ventral scute and immediately in front of the spinnerets is a small sclerite on which is situated the tracheal spiracle. The longitudinal lateral folds reinforced with sclerites as described in the male also occur in the female.

*Spinnerets*. Similar to those of the male and provided with similar stridulating ridges on the anterior pair.

*Epigynum*. The form of the epigynum in surface view is shown in pl. II, fig. 19, and as a transparent object in pl. V, fig. 39.

**Habits.** Specimens kept in the laboratory did not spin a web or make any nest. The spider occurs in grass-tussocks, moss, and other situations close to the ground, and is usually found during the months May to September.

**Localities.** The type specimens were found in grass-tussocks on the eastern slopes of the Domain, Hobart. Co-types were collected at Glen Dhu, the Punch Bowl, and Trevallyn, near Launceston.

***Hadrotarsus fulvus*, sp. n.**

**Male.** Measurements in millimetres:—

Total length	1.3974
Length of cephalothorax	0.4932
Width of cephalothorax	0.4658
Length of abdomen	0.9727
Width of abdomen	0.6028

Leg	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
1	0.3699	0.2055	0.3014	0.1644	0.3014	1.3426
2	0.3014	0.1918	0.2603	0.1507	0.2877	1.1919
3	0.2740	0.1918	0.2466	0.1507	0.2740	1.1371
4	0.3699	0.2329	0.3562	0.2055	0.3562	1.5207
Palp	0.1918	0.0822	0.0411		0.2548	0.5699

**Colour.** Yellowish brown without markings. Ocular area black anteriorly. Two dorsal muscle spots on abdomen.

**Carapace.** Almost as wide as long (pl. III, fig. 20). Thoracic groove wanting. Clothed with a few minute scattered hairs, otherwise the surface is smooth, shining and glabrous.

**Eyes.** The eye-group occupies about  $\frac{1}{2}$  of the width of the carapace in the eye-region. The eight eyes are arranged in two rows. Viewed from above the front row appears slightly recurved. From the front it is seen to be strongly procurved. The posterior row is procurved. PME large, flat, and reniform. AME dark, the other eyes pearly white. Ratio of eyes AME : ALE : PME : PLE = 3 : 3 : 6 (long) : 3. AME separated from each other by  $\frac{1}{2}$  of their diameter and from PME by about the same distance. ALE in contact with both AME and PLE, forming a crescent-shaped row. Height of clypeus in front of AME is about twice the diameter of AME.

**Chelicerae.** Conical, small, and vertical. Their inner edges obliquely diverging. Lateral condyles, teeth, and scopula wanting. A row of three straight setae near base of fang. Fangs moderately long and falcate. They lie transversely and cross each other (pl. III, fig. 23).

**Maxillae.** Converging in front of labium. Apex pointed, membranous, and pellucid. A serrula consisting of a row of eight teeth is situated on the antero-lateral margin, and a small scopula on the inner margin near the apex.

**Labium.** Triangular with apex rounded. Wider than long in ratio 5 : 4. Provided with three pairs of setae. The apex is colourless and difficult to see.

**Sternum.** Shield-shape, convex, longer than wide in ratio 25 : 23. The posterior end is truncate and separates the fourth coxae. The middle of the sternum is smooth and glabrous, the sub-marginal region clothed with a few setae which point inwards (pl. III, fig. 24).

*Legs.* 4.1.2.3. Tarsi of first pair of legs swollen. Integument lightly clothed with barbed hairs. Two trichobothria on each tibia and one near the apex of each metatarsus, elsewhere none. Spines absent. Metatarsi much shorter than tarsi. Tarsal claws two, situated on an onychium, which also carries a pair of barbed hairs resembling spurious claws. Claws of the first three pairs of legs pectinated on both margins, those of the fourth pair on one margin only. The number of teeth on each claw is given in the following table:—

	Prolateral Claw		Retrolateral Claw	
	Teeth on Promargin	Teeth on Retromargin	Teeth on Promargin	Teeth on Retromargin
Leg 1	10	1	9	1
Leg 2	9	1	8	1
Leg 3	9	1	1	6
Leg 4	7	0	0	6

Scopulae and claw tufts wanting.

*Palpi.* The form of the right palpus is shown in pl. III, figs 21 and 22. The tibia is very short, saucer-shaped, and without apophyses. It has a small trichobothrium. The cymbium is very large and the alveolus is on the retrolateral side. The embolus is long and thread-like. It arises on the retrolateral side, and passes down and round the margin of the cymbium. It then curves back and ends near its point of origin on the retrolateral side.

*Abdomen.* The dorsal surface is covered by a hard chitinous shield, which has a small median V-shaped notch in the anterior margin (pl. III, fig. 20). On each side of the notch are a few short, thick setae. Elsewhere the scute is lightly clothed with small hairs. There is a pair of large conspicuous muscle spots near the middle of the scute. The front half of the ventral surface of the abdomen is covered by a large epigastric scute, which anteriorly surrounds the base of the pedicle (pl. III, fig. 24). Immediately behind the posterior margin of this scute is the epigastric furrow, in which lie the pulmonary spiracles, one on each side. Behind the furrow is a transverse row of three small scutes, the two lateral ones of which are fused to the epigastric scute round the outer ends of the pulmonary spiracles. The posterior half of the ventral surface is mainly covered by a large ventral scute, near the antero-lateral angles of which is a pair of very small sclerites, one on each side. Between the ventral scute and the spinnerets is a transverse row of three small sclerites, the middle one of which bears the tracheal spiracle, which is immediately in front of the spinnerets. The lateral sclerites in the row sometimes show a tendency to fuse with the large ventral scute, but in most cases they are quite separate. On each side of the abdomen below the dorsal shield the integument forms three longitudinal folds, two of which are continuous anteriorly above the pedicle and posteriorly above the anal tubercle.

*Spinnerets.* Six. There is a small sclerite on each side of the spinnerets, but the group is not surrounded by a chitinous ring. Anterior and posterior spinnerets are two-segmented, the apical segment being very short and conical. As in *H. ornatus* the inner surface of the basal segment of each anterior spinneret is marked by a series of fine transverse ridges to form what appears to be a stridulating organ. (Pl. III, fig. 27, shows the anterior spinnerets of the female.



which are similar to those of the male.) The middle spinnerets are very small and one-segmented. The posterior spinnerets are provided with a spigot having a very wide tube.

**Female.** Measurements in millimetres:—

Total length	1.4248
Length of cephalothorax	0.5206
Width of cephalothorax	0.4521
Length of abdomen	0.9316
Width of abdomen	0.6302

Leg	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
1	0.3699	0.2055	0.2603	0.1507	0.2466	1.2330
2	0.3151	0.1781	0.2329	0.1507	0.2603	1.1371
3	0.3014	0.1781	0.2192	0.1507	0.2740	1.1234
4	0.4110	0.2329	0.3425	0.2055	0.3288	1.5207
Palp	0.1096	0.0685	0.0822		0.1370	0.3973

**Colour.** The female resembles the male in colour and general appearance. Hence, only the following characters need be described:—

**Eyes.** The eight eyes are arranged in two rows. The anterior row viewed from above appears very slightly recurved; viewed from in front, it is distinctly procurved, the lateral eyes being nearer the edge of the clypeus than are the median eyes. The posterior row is procurved. Ratio of eyes AME : ALE : PME : PLE = 4 : 4 : 7 (long) : 4. The width of the eye-group is slightly less than the width of the carapace in the region of the eyes. AME are separated from each other by a space equal to their diameter and from PME by about half this distance. They are in contact with ALE, which are in contact with PLE. PME are large, flat, and reniform. They are contiguous with each other but separated from PLE by a space equal to half the diameter of AME. The quadrangle formed by the median eyes is wider in front than behind in ratio 9 : 8. Its length is greater than its anterior width in ratio 14 : 9. AME are dark, the other eyes pearly white. The height of the clypeus in front of AME is about  $9/4$  times the diameter of AME.

**Chelicerae, Maxillae, Labium, and Sternum.** As in the male.

**Legs.** 4.1.2.3. In form, clothing, and arrangement of the trichobothria the legs resemble those of the male. However, they are somewhat shorter, except in the case of the fourth pair, and there is a slight difference in the pectination of the claws on the third and fourth tarsi, as indicated in the following table:—

	Prolateral Claw		Retrolateral Claw	
	Teeth on Promargin	Teeth on Retromargin	Teeth on Promargin	Teeth on Retromargin
Leg 1 . . .	10	1	9	1
Leg 2 . . .	9	1	8	1
Leg 3 . . .	8	1	1	6
Leg 4 . . .	6	0	0	5

*Palpi.* Lightly clothed with barbed setae. A single trichobothrium is present near the middle of the tibia. The tarsal claw is curved and expanded so that the promarginal teeth form a row, which is almost transverse to the long axis of the tarsus. The claw is carried on a short onychium and has eight teeth on the promargin and one on the retromargin (pl. III, fig. 25).

*Abdomen.* The dorsal surface is covered by a hard oval shield resembling that of the male. There is a small V-shaped median notch in the anterior margin, and on each side of the notch a number of coarse setae. The rest of the shield is clothed with small hairs. The ventral surface is provided with a ring-like sclerite surrounding the base of the pedicle. Behind this is a median shield, on which the epigynum is situated. On each side of this median shield, but separated from it is an elongate pulmonary sclerite covering the book-lung. The lung-slit is situated between the posterior end of the pulmonary sclerite and a smaller sclerite immediately behind it. Posterior to the epigynum is a small triangular scute, on each side of which are two small sclerites, one behind the other. The posterior half of the ventral surface of the abdomen is covered by a large rectangular scute, behind which is a transverse row of three small sclerites. The median sclerite of the row is immediately in front of the spinnerets and bears the tracheal spiracle (pl. III, fig. 26). The sides of the abdomen have a series of longitudinal folds as in the male.

*Spinnerets.* Six. The anterior pair and posterior pair two-segmented, the apical segment small and conical. The posterior pair slightly smaller than the anterior pair. The middle spinnerets are very small and usually hidden by the others. On the inner surface of the basal segment of each anterior spinneret the chitin is thickened and provided with fine transverse ridges forming a stridulating organ as in the male (pl. III, fig. 27).

*Epigynum.* The form of the epigynum in surface view is shown in pl. III, fig. 28, and in transparent preparations in pl. V, fig. 40. In surface view it appears as a somewhat triangular depression, from the apex of which there projects backward a short scape or ovipositor. The spermathecae are visible through the integument as two dark circular areas, one on each side of the scape.

*Habits.* Specimens kept in the laboratory did not spin a web or make any nest. A male and female were observed in copulation on 24th August, 1934. The position adopted is shown in pl. IV, fig. 29. Unfortunately the female died without making an egg-sac. The spider is usually found during the months May to September. It occurs in grass-tussocks, moss, and lichens.

*Localities.* The type-specimen ( $\delta$ ) was collected at Fingal and the  $\eta$  on the Domain, Hobart. Co-types were found at Trevallyn, Launceston. My collection also contains a male, found by Mr. C. Oke in Victoria.

#### ***Hadrotarsus setosus*, sp. n.**

**Male.** Measurements in millimetres:—

Total length	1.4385
Length of cephalothorax	0.5891
Width of cephalothorax	0.5343
Length of abdomen	1.1097
Width of abdomen	0.7585

Leg	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
1	0.4110	0.2329	0.3288	0.1781	0.3288	1.4796
2	0.4110	0.2055	0.2740	0.1781	0.2877	1.3563
3	0.3699	0.2055	0.2740	0.1644	0.2877	1.3015
4	0.4795	0.2740	0.3562	0.2466	0.3562	1.7125
Palp	0.3151	0.1096	0.0685		0.3425	0.8357

*Colour.* Light chestnut brown without markings. Ocular area black anteriorly. Two large muscle spots near middle of dorsal surface of abdomen.

*Carapace.* Slightly longer than wide. Clothed with a few small scattered hairs. Thoracic groove wanting. Sides well rounded. Front somewhat narrowed (pl. IV, fig. 30).

*Eyes.* The eye-group occupies almost the whole width of the carapace in the region of the eyes. The eight eyes are arranged in two rows. Viewed from above the front row is slightly recurved, but viewed from in front it is strongly procurved, ALE being nearer the edge of the clypeus than are AME. The posterior row is procurved. AME dark, the other eyes pearly white. Posterior median eyes large, flat, and reniform (pl. IV, fig. 31). Ratio of eyes AME : ALE : PME : PLE = 4 : 4 : 6 (long) : 4. AME separated from each other by  $\frac{1}{2}$  of their diameter and from PME by slightly more than  $\frac{1}{2}$  of their diameter. AME are in contact with ALE, which are in contact with PLE. The PME are almost in contact with each other but are separated from PLE by  $\frac{1}{2}$  the diameter of AME. The quadrangle formed by the median eyes wider in front than behind in ratio 9 : 8. Its length is greater than its anterior width in ratio 10 : 9. The height of the clypeus in front of AME is equal to nearly three times the diameter of AME.

*Chelicerae.* Very small, conical, and lacking teeth, scopula and lateral condyles. Fangs long, sharp, and falcate.

*Maxillae.* Triangular, converging in front of labium. Apex pointed, membranous, and pellucid. A serrula consisting of a row of about ten teeth is situated on the antero-lateral margin.

*Labium.* Triangular with rounded apex. Nearly twice as wide as long.

*Sternum.* Convex, rounded and triangular. Longer than wide in ratio 27 : 24. Posterior end truncated. Fourth coxae well separated. Middle of sternum smooth and glabrous, the sub-marginal region with a few setae which point inwards (pl. IV, fig. 32).

*Legs.* 4.1.2.3. Tarsi of first pair distinctly swollen. Metatarsi much shorter than tarsi. Two trichobothria on each tibia and one near the apex of each metatarsus. Clothing of legs consists of barbed hairs, but spines, scopulae, and claw-tufts are absent. Two tarsal claws situated on an onychium are present. The onychium also carries a pair of barbed setae resembling spurious claws. The pectination of the true claws resembles that of the preceding species. The following table gives the number of teeth on each claw:—

	Prolateral Claw		Retrolateral Claw	
	Teeth on Promargin	Teeth on Retromargin	Teeth on Promargin	Teeth on Retromargin
Leg 1	9	1	7	1
Leg 2	7	1	7	1
Leg 3	6	1	1	5
Leg 4	5	0	0	5

*Palpi.* The form of the right palpus is shown in pl. IV, figs 33 and 34. The tibia is very short and saucer-shaped. It carries a single trichobothrium. The cymbium is large and spoon-shaped with the alveolus more or less on the retro-lateral side. The embolus is long and thread-like. It makes about three complete circular turns on the side of the genital bulb. In the single specimen examined the free end of the embolus projected beyond the cymbium and then curved back as shown in the figure. It is probable, however, that the end had become dislodged from the normal resting position. No apophysis is present on the tibia or tarsus.

*Abdomen.* The dorsal surface is covered by a hard shield which has a small median V-shaped notch on its front margin. On each side of the notch are several setae which are longer and more slender than those of the two preceding species. Moreover, the hairs which cover the rest of the dorsal shield are coarser than in the case of either *H. fulvus* or *H. ornatus*. There are two conspicuous muscle spots near the middle of the scute. The anterior half of the ventral surface is covered by a large epigastric scute, which extends forward and surrounds the pedicle (pl. IV, fig. 32). Behind the large scute is a transverse row of three small scutes, the middle one of which is smaller than the lateral ones. The latter are fused to the posterior angles of the large epigastric scute leaving, on each side, a narrow transverse notch, which opens towards the middle. In the two notches thus formed the openings of the two book-lungs are situated. The posterior half of the ventral surface of the abdomen is mainly covered by a large ventral scute. Situated near the antero-lateral angles of the ventral scute are two small sclerites, one on each side. Immediately in front of the spinnerets and partly hidden by the posterior margin of the large ventral scute is a small sclerite, on which is situated the tracheal spiracle. The integument between the dorsal and ventral surfaces of the abdomen forms three longitudinal folds, two of which appear to be continuous above the pedicle in front and the anal tubercle behind.

*Spinnerets.* Six. There is a small sclerite on each side of the spinnerets, but the group is not surrounded by a chitinous ring. Each spinneret, however, has a hard investment of chitin. The anterior pair consist of a large basal segment and a small conical apical segment. The inner surface of the basal segment is thickened and marked with stridulating ridges as in the two preceding species. The posterior spinnerets are slightly smaller than the anterior pair. They are two-segmented, the apical segment being very small and sunken in the end of the basal segment. The middle spinnerets are very small and almost hidden by the others.

*Locality.* Victoria. A single male specimen collected by Mr. C. Oke.

#### NOTES ON THE INTERNAL ANATOMY.

The following notes refer to the main features of the internal anatomy of *H. ornatus* and *H. fulvus*. Specimens were fixed in Carnoy's Fluid and studied in serial sections stained with haematoxylin and eosin. As only one specimen of *H. setosus* was available, no attempt was made to examine its internal structure.

*Abdominal Musculature.* The musculature of the abdomen is much reduced. There is a pair of latero-cardiac muscles, which arise from the dorsal shield and pass obliquely downwards, one on each side of the heart, and close to the second pair of ostia. They are inserted in the posterior end of the lorum of the pedicle (pl. V, fig. 35). Some distance behind the latero-cardiac muscles is a pair of strong dorso-ventral muscles, which arise from the two conspicuous muscle spots near the middle of the dorsal shield and pass downwards to be inserted in two pairs of

median endosternites. These are close together and above the epigastric furrow. They probably represent the endosternites of the 8th and 9th body-segments (i.e., the 2nd and 3rd segments of the abdomen). Hence the dorso-ventral muscle bands, which appear single, are probably composed of the dorso-ventral muscles of the two segments. Connecting the margin of the dorsal shield with the ventral sclerites are numerous short dorso-ventral muscles which do not appear to have any segmental arrangement. In addition to the muscles mentioned, there are two pairs of dorso-ventral muscles in the pedicle and a series of longitudinal ventral muscles, as shown in pl. V, fig. 35.

*Digestive System.* The thoracenteron is of the classic type. It consists of four pairs of caeca extending outwards and downwards to the coxae of the four pairs of legs.

The primary branching of the chylenteron gives rise to a single midventral diverticulum, two pairs of lateral diverticula and one pair of dorsal diverticula. The midventral diverticulum and the first pair of lateral diverticula arise close together from the main tube a short distance behind the pedicle. Farther back the second pair of lateral diverticula are given off and posterior to these the dorsal diverticula arise.

Each maxilla contains a single oblong multi-cellular gland, which is about two-thirds the length of the endite. It has a large lumen which acts as a reservoir. The ducts of the gland are not clearly visible, but they appear to open on the inner margin of the maxilla near the base of the scopula. A rostral gland is also present. It is rounded without any appearance of being bilobed. It opens into a wide transverse slit-like aperture on the front of the rostrum near the apex (pl. V, fig. 38).

*Excretory System.* The usual pair of biramous malpighian tubules are present. They open into the gut just in front of the stercoral pouch. No trace of coxal glands in the cephalothorax could be found.

*Poison Glands.* These glands are endocephalic. They are fusiform in shape and situated in an almost vertical position. In *H. ornatus* they extend from immediately below the posterior median eyes into the base of the chelicerae. In *H. fulvus* the glands are similar in shape, but smaller.

*Silk Glands.* In the females of both *H. ornatus* and *H. fulvus* two very large pear-shaped glands are situated below the stercoral pouch (pl. V, fig. 36). They extend forward as far as the ovary. Posteriorly they open by the large spigot on the hind spinnerets.

Six cylindrical glands are also present. These are situated, three on each side, one above the other and close to the large pear-shaped glands. They extend forward nearly to the front of the ovary and their anterior ends are somewhat bent or twisted. Of the three glands on each side the uppermost one opens on the corresponding middle spinneret, the other two on the inner side of the posterior spinneret. In the males these cylindrical glands appear to be absent. The wall of the glands is very thick and stains deeply.

The anterior spinnerets are supplied with silk from a large number of small pyriform glands arranged in two groups, one on each side and close to the basal segments of the spinnerets.

*Reproductive System.* The appearance of the vaginal system of *H. ornatus* and *H. fulvus*, as seen in transparent preparations, is shown in pl. V, figs 39 and 40. In both species the afferent ducts leading to the spermathecae are very long. In

*H. ornatus* they are coiled so as to form a narrow spiral surrounded by a wider spiral. In *H. fulvus* the ducts are not coiled, but form several loops which extend laterally as far as the book-lungs. In both species the spermathecae are large and rounded. In *H. fulvus* each is connected with a spermathecal gland situated towards the front of the vaginal system.

In the males the vasa deferentia open into a large spherical vesicula seminalis situated near the genital aperture.

*Circulatory System.* The heart is fusiform and curved dorso-ventrally. It has two pairs of ostia (pl. V, fig. 37). The anterior pair are the larger and are situated in a dorso-lateral position at the front of the heart. The second pair are smaller and also dorso-lateral in position. The descending latero-cardiac muscles pass close to them. The interval between the first and second pair of ostia is slightly less than that between the second pair and the posterior end of the heart.

*Respiratory System.* The organs of respiration consist of a single pair of book-lungs and a system of tracheal tubes. The book-lungs occupy the normal position, one on each side, in front of the epigastric furrow. In *H. ornatus* each book-lung has eleven leaves and in *H. fulvus* nine. The tracheal system is confined to the abdomen and is composed of four simple tubes, which unite in a short atrium before opening on the exterior by the single median spiracle in front of the spinnerets. Two of the tubes are short and run straight forward parallel with the longitudinal ventral muscles to end near the epigastric furrow. The other two tubes pass outwards and run obliquely forwards converging on the heart. They pass through the wall of the pericardium in front of the latero-cardiac muscles and enter the pericardial cavity, where they lie, one on each side of the heart. They end near the front of the heart.

#### NEW DEFINITION OF THE FAMILY HADROTARSIDAE

Dipneumone, quadrostiate spiders. Carapace without thoracic groove. Eight eyes in two rows. Posterior median eyes large, flat, and reniform. Chelicerae without teeth and lateral condyles. Poison glands endocephalic. Fang falcate. Maxillary lobes strongly converging and provided with a serrula. Sternum triangular and rounded with truncated posterior end separating the fourth coxae. Lip free, wider than long. Tarsal segments of first pair of legs swollen. Metatarsi much shorter than tarsi. Trochanters without notch. Two trichobothria on each tibia and one on each metatarsus. Legs lacking spines, scopulae and claw-tufts. Two tarsal claws situated on an onychium. The claws of the first three pairs of legs pectinate in a double row, those of the fourth pair in a single row. Dorsal surface of abdomen covered with a hard shield, ventral surface with an epigastric scute, a ventral scute and several smaller sclerites. In the males the epigastric scute surrounds the pedicle. The two pulmonary spiracles situated one on each side in the epigastric furrow. The single median tracheal spiracle immediately in front of the spinnerets leads into a short atrium which gives rise to four tracheal tubes, which are confined to the abdomen. Six spinnerets. Anterior spinnerets contiguous, two-segmented and with transverse stridulating ridges on the inner surface of the basal segment. Median spinnerets small, contiguous and composed of one segment. Posterior spinnerets two-segmented and slightly shorter than anterior pair. Integument with barbed hair. Genital bulb of male provided with a long thread-like embolus. Epigynum of female complex.

The family Hadrotarsidae as defined above includes the four species of the genus *Hadrotarsus*. The position of *Gmogala scarabaea* Keyserling must remain uncertain until the type specimen is again examined and described in greater detail. However, it has so many features in common with species belonging to the genus *Hadrotarsus* that it might be expected to have a similar respiratory system. Pocock's description of the tracheal spiracles as a 'pair of contiguous round dark spots, surrounded by a circular rim' might apply equally well to a small sclerite with a pair of round dark spots representing the small cup-like depressions from which a pair of setae had been rubbed off or removed. While Pocock corrected some of the errors made by Keyserling in the original description of *G. scarabaea*, he has left students in doubt with regard to several important features of the external anatomy.

Acknowledgments are made to the Trustees of the John Ralston Bequest, under whose auspices the above work was carried out.

## REFERENCES

- BERLAND, L., 1932.—*Les Arachnides*, Paris, p. 359.  
 CROSBY, C. R., 1934.—*Bull. Brooklyn Ent. Soc.*, XXIX, p. 21.  
 GERHARD, U. and KASTNER, A., 1938.—*Araneae*: in Kükenthal-Krumbach's *Handb. d. Zool.*, III, 2 (2), p. 592.  
 KEYSERLING, E., 1890.—L. Koch, *Arachniden Australiens*, Suppl., p. 269.  
 PETRUNKEVITCH, A., 1933.—*Trans. Conn. Acad.*, 31, p. 305.  
 POCOCK, R. I., 1903.—*Ann. Mag. Nat. Hist.* (7), 11, p. 619.  
 RAINBOW, W. J., 1902.—*Rec. Aust. Mus.*, IV, 7, p. 815.  
 THORELL, T., 1881.—*Studi Ragni Mal. e Pap.*, III, p. 190.

## PLATE I.

### *Hadrotarsus ornatus*, sp. n.

- FIG. 1.—Dorsal view of male. Legs of left side omitted.  
 FIG. 2.—Eyes of male viewed from above.  
 FIG. 3.—Right chelicera of male viewed from the front.  
 FIG. 4.—Maxillae and labium of male.  
 FIG. 5.—Leg of first pair showing swollen tarus and the position of the trichobothria on the tibia and metatarsus.  
 FIG. 6.—Leg of second pair showing position of the trichobothria.  
 FIG. 7.—Ventral view of tarsal claws of first leg of male.  
 FIG. 8.—Ventral view of tarsal claws of third leg of male.  
 FIG. 9.—Ventral view of tarsal claws of fourth leg of male.  
 FIG. 10.—Left palpus of male showing genital bulb and the coiled embolus.  
 FIG. 11.—Terminal apophysis of genital bulb.  
 FIG. 12.—End of embolus showing barb near the tip.

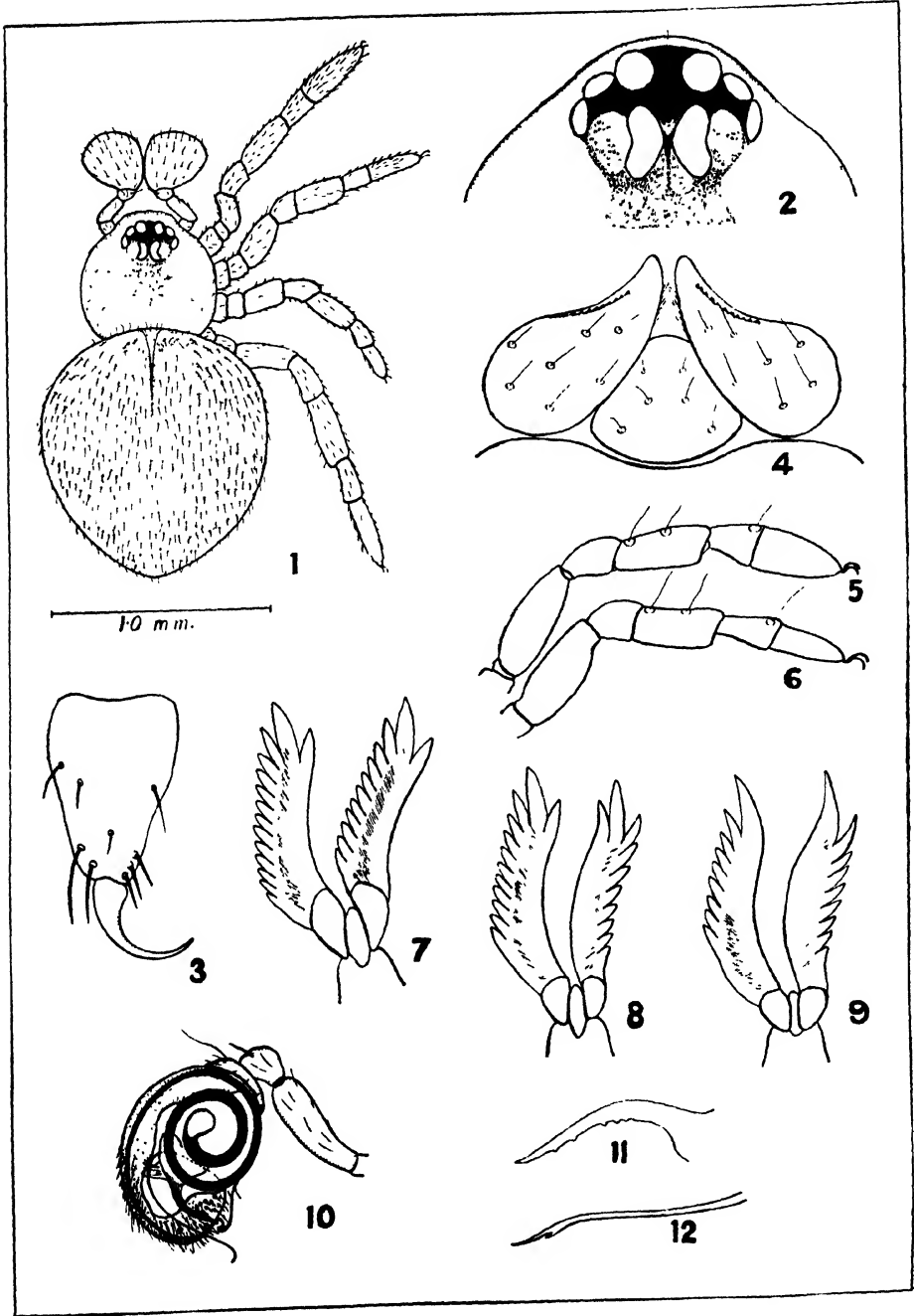




PLATE II.

*Hadrotarsus ornatus*, sp. n.

FIG. 13.—Ventral view of sternum and abdomen of male.

FIG. 14.—Anterior spinnerets of male showing the tranverse ridges probably used in stridulating.

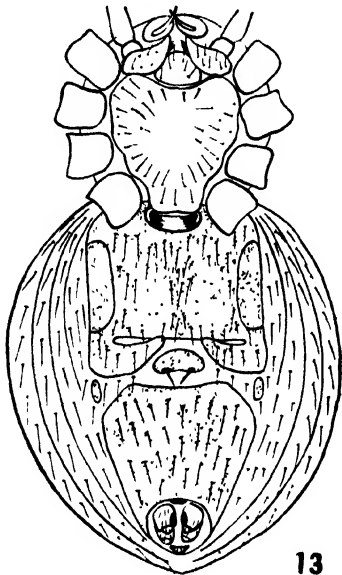
FIG. 15.—A posterior spinneret of male showing the large spigot.

FIG. 16.—A middle spinneret of male.

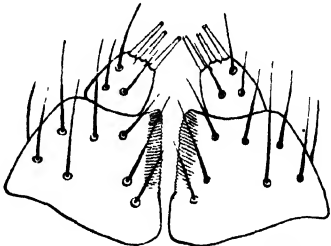
FIG. 17.—Ventral view of tarsal claw of left palpus of female. *p.t.*, promarginal teeth; *r.t.*, retro-marginal tooth.

FIG. 18.—Ventral view of sternum and abdomen of female.

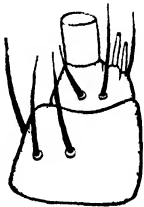
FIG. 19.—Epigynum in surface view.



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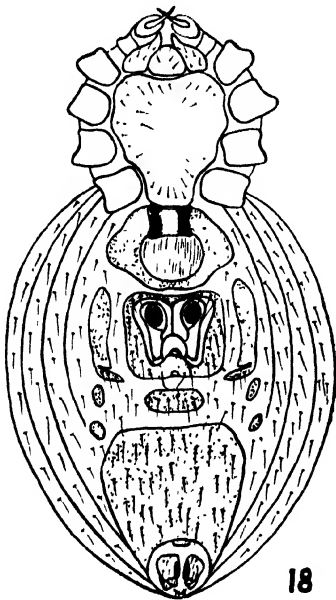
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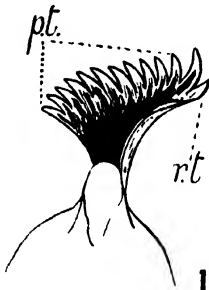
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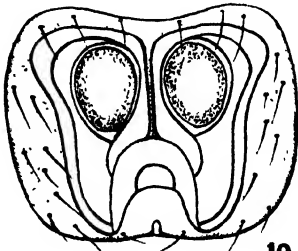
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PLATE III.

*Hadrotarsus fulvus*, sp. n

FIG. 20.—Dorsal view of male. Legs of left side omitted

FIG. 21.—Retrolateral view of right palpus of male.

FIG. 22 Prolateral view of right palpus of male.

FIG. 23.—Right chelicera of male viewed from the front.

FIG. 24.—Ventral view of sternum and abdomen of male. *ps.*, position of pulmonary spiracle;  
*ts.*, tracheal spiracle.

FIG. 25.—Ventral view of tarsal claw of right palpus of female.

FIG. 26.—Ventral view of sternum and abdomen of female.

FIG. 27.—Anterior spinnerets of female showing the transverse stridulating ridges. *ts.*, tracheal  
spiracle on small sclerite in front of spinnerets.

FIG. 28.—Epigynum in surface view.

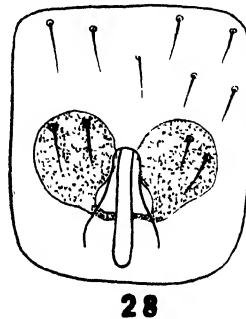
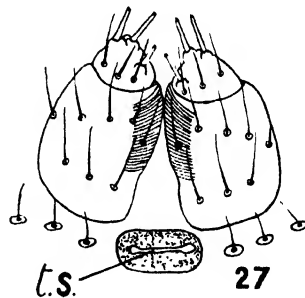
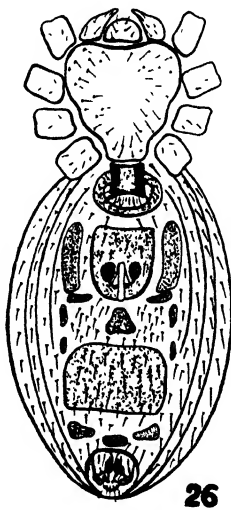
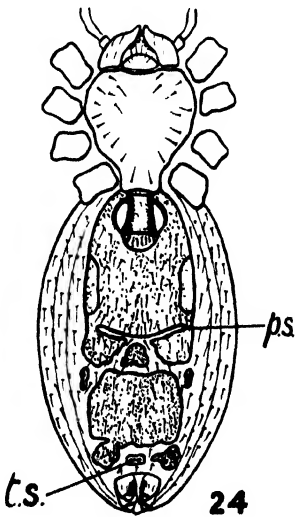
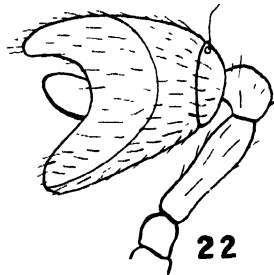
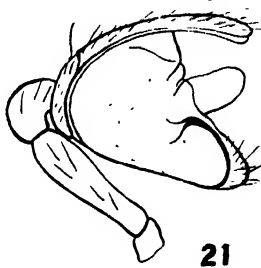
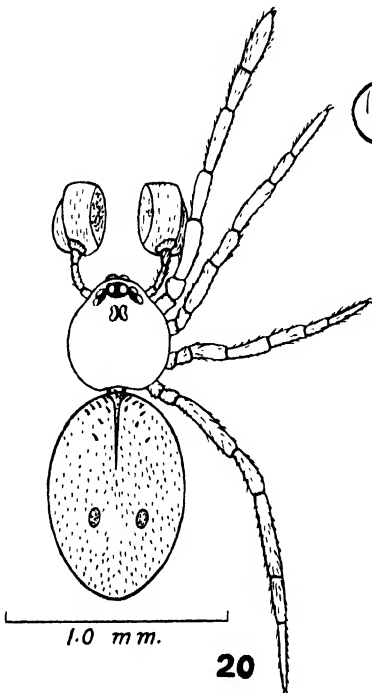


PLATE IV.

*Hadrotarsus fulvus*, sp. n.

FIG. 29.—Lateral view of male and female in copulation.

*Hadrotarsus setosus*, sp. n.

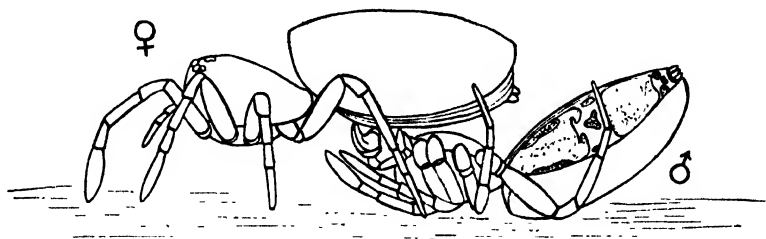
FIG. 30.—Dorsal view of male. Legs and palpi omitted.

FIG. 31.—Eyes of male viewed from above.

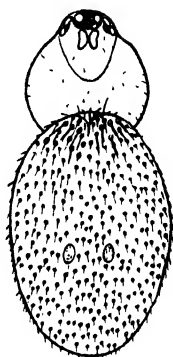
FIG. 32.—Ventral view of sternum and abdomen of male.

FIG. 33.—Retrolateral view of right palpus of male showing coiled embolus.

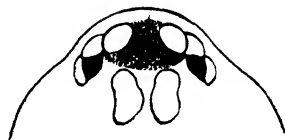
FIG. 34.—Prolateral view of right palpus of male.



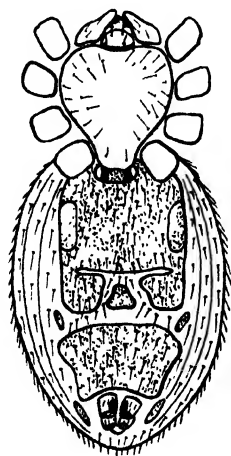
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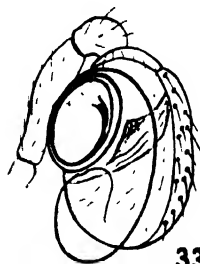
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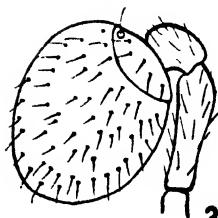
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PLATE V.

*Hadrotarsus ornatus* sp. n.

FIG. 35.- Muscles of abdomen. *d.v.* VIII and IX, dorso-ventral muscles of body segments VIII and IX. *lc.*, latero-cardiac muscle. *ml.* VIII, IX, and X, median longitudinal muscles of body segments VIII, IX, and X. *sp.*, stercoral pouch.

FIG. 36.—Transverse section of abdomen of female passing through the front of the stercoral pouch. *c.g.*, cylindrical silk-glands. *d.d.* dorsal diverticula of gut; *lt.*, lateral tracheal tube. *sg.*, large pear-shaped silk gland. *r.d.* midventral diverticulum of gut. *vt.* ventral tracheal tubes.

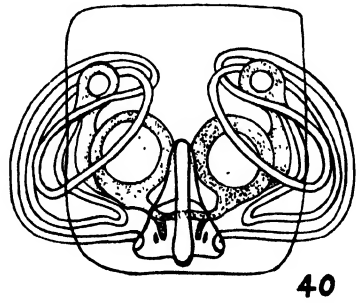
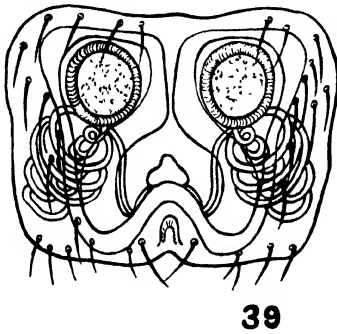
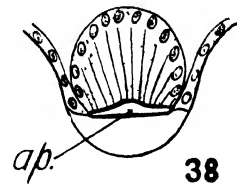
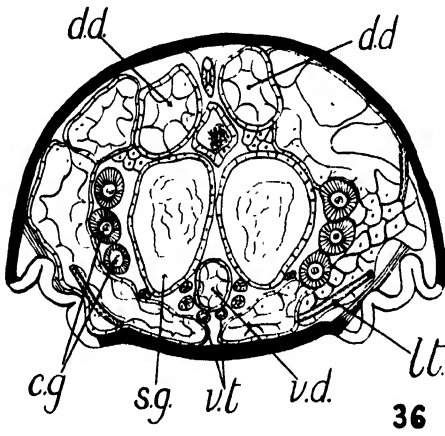
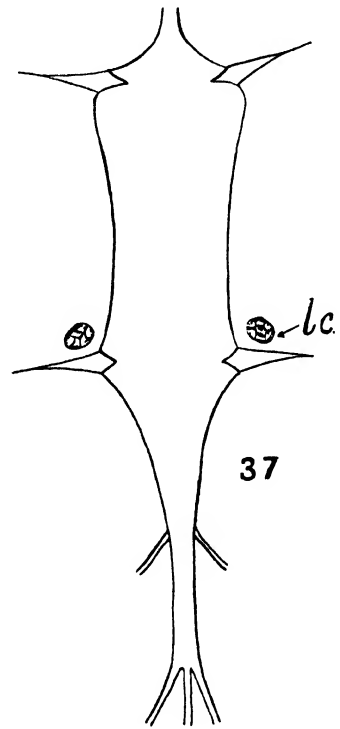
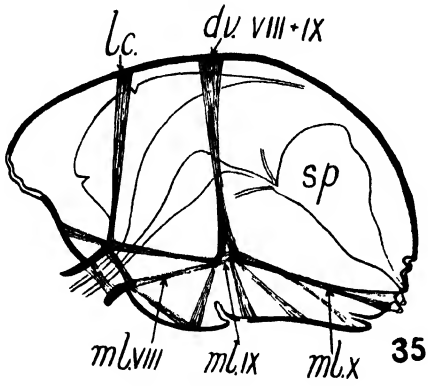
FIG. 37.—Dorsal view of heart showing the position of the four ostia. *lc.*, latero-cardiac muscle.

FIG. 38.—Frontal section through rostrum showing the rostral gland. *ap.*, slit-like aperture of gland.

FIG. 39.—Epigynum as seen in transparent preparations.

*Hadrotarsus fulvus*, sp. n.

FIG. 40.— Epigynum as seen in transparent preparations.







# The Royal Society of Tasmania

1942

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**Patron:**

His Majesty the King.

**President:**

His Excellency Sir Ernest Clark, K.C.B., K.C.M.G., C.B.E.

**Vice-Presidents:**

H. Allport, LL.B., 1941-42.

A. L. Meston, M.A., 1942-43.

**Council:**

N. P. Booth, 1942, 1943, 1944.

H. D. Gordon, B.Sc., Ph.D., 1942, 1943, 1944.

W. H. Clemes, B.A., B.Sc., 1942, 1943.

L. Cerutti, B.A., Dip.Ed., 1942, 1943.

W. L. Crowther, D.S.O., M.B., V.D., 1942.

E. E. Unwin, M.Sc., 1942.

**Standing Committee:**

W. L. Crowther, E. E. Unwin, V. V. Hickman, J. Pearson.

**Hon. Treasurer:**

S. Angel.

**Hon. Editor:**

Joseph Pearson, D.Sc. (Manc.), D.Sc. (Liverpool), F.R.S.E., F.L.S.

**Auditor:**

H. J. Exley, M.A.

**Secretary and Librarian:**

Joseph Pearson.

## Annual Report, 1942

The Annual Meeting was held in the Society's Room, Tasmanian Museum and Art Gallery, Hobart, on the 9th March, 1942.

The following Office-bearers were elected:—

Vice-President: Under the Society's Rules, Mr. E. E. Unwin retired from the office of Vice-President, and Mr. A. L. Meston was appointed in his place (retiring 1944).

Treasurer: Mr. S. Angel.

Council: Under the Rules, Dr. A. N. Lewis and Dr. V. V. Hickman retired from the Council, and the following members were elected to the Council in their place:—

Mr. N. P. Booth (retiring 1945).

Dr. H. D. Gordon (retiring 1945).

The Council made the following appointments at its first meeting:—

Secretary and Librarian: Dr. Joseph Pearson.

Assistant Librarian: Mrs. Clive Lord.

Standing Committee: Dr. W. L. Crowther, Mr. E. E. Unwin, Dr. V. V. Hickman, and the Secretary.

The Council elected the following two Trustees to serve on the Board of Trustees of the Tasmanian Museum and Art Gallery and the Botanical Gardens:—  
Mr. W. H. Clemes and Mr. E. E. Unwin.

Nine meetings were held during the year (see proceedings for abstracts of papers). In addition, scientific papers were submitted for publication and have been printed in the present volume.

### *Library*

It was agreed, on the recommendation of the Council, to make the following changes in the hours of opening the Society's Library:—

Mondays: 10 a.m. to 1 p.m. and 2 p.m. to 5 p.m.

Wednesdays and Fridays: 10 a.m. to 1 p.m.

Also at 7.30 to 8 p.m. on the evenings when a General Meeting is held.

During the year 138 volumes were added to the Library in addition to a number of reports and pamphlets from British and foreign institutions and learned societies. The number of institutions on the Exchange List for the year was 270, being made up of 124 British, 54 American, and 92 from other parts of the world. No foreign exchanges have been sent since the 1938 volume, and subsequent issues are being held until the conclusion of the war. This year it was felt advisable also to withhold British and American exchanges. The Library now consists of 20,264 volumes.

The sum of £22 16s. 9d. was spent on books during the year, and the account allocated as follows:—

	£	s.	d.
General Fund	1	4	2
R. M. Johnston Fund	9	11	3
Morton Allport Memorial Fund	6	14	0
Beattie Memorial Fund	5	7	4

In addition, the Tasmanian Museum spent £4 1s. 3d. on books, which have been placed in the Society's Library for safekeeping, and are available to members.

### *Membership*

The Society consists of the following members:—

	1941.	1942.
Honorary Members	2	2
Corresponding Members	3	3
Life Members	7	6
Ordinary Members	210	213
Associate Members	5	4
	<hr/> 227	<hr/> 228

During the year 14 names were removed from the list of Ordinary Members owing to deaths, resignations, etc., and 17 new members were elected.

Also, the resignation of one Associate Member was received, and one Associate Member was transferred to Ordinary Membership, while one new Associate Member was elected.

The Council regrets having to record the deaths of the following members during the year:—Dr. Gregory Sprott, Mrs. S. H. Hancox, Mr. F. J. Heyward.

### *Printing of Papers and Proceedings*

Once again the Government has very generously printed the Papers and Proceedings. The Council wishes to record its appreciation of this assistance.

## Abstract of Proceedings

9TH MARCH, 1942

### *Annual Meeting*

The Annual Meeting was held in the Society's Room, Tasmanian Museum. The President, His Excellency the Governor, presided.

The following were elected Office-bearers and members of the Council for 1942:—Mr. A. L. Meston was elected Vice-President in the place of Mr. E. E. Unwin, who retired under Rule 12; Mr. N. P. Booth and Dr. H. D. Gordon were elected in the places of Dr. A. N. Lewis and Dr. V. V. Hickman, who retired under Rule 21; Treasurer, Mr. S. Angel.

Mr. H. J. Exley was appointed Hon. Auditor.

Mr. T. A. Gepp was elected a member of the Society.

Dr. W. L. Crowther read a paper entitled 'The Life of Dr. Fordyce Storey in Tasmania, 1829-1885', which was prepared by Mrs. J. A. McElroy.

13TH APRIL, 1942

A meeting was held in the Society's Room on this date. Mr. Henry Allport, Vice-President, presided.

The following were elected members of the Society:—Mrs. E. A. Charles, Miss L. van Gooch, Mr. J. C. Bennett, Mr. M. Bennett, Mr. F. C. Wolfhagen.

Mr. E. E. Unwin delivered an illustrated lecture entitled 'The Voices of Animals', of which the following is an abstract:—

An inquiry into the purposeful sounds produced by animals as a means of communication, illustrated by slides and pictures, as well as gramophone recordings of animal voices. Some attempt was made to describe the sound recording apparatus as well as the sound producing—for hearing sounds is as important as making them.

The lecture covered the following aspects:—

Tapping sounds.—Spiders, Booklice, Deathwatch, Beetles, Termites.

Buzzing sounds.—Blowfly, Mosquito, Bees, and Wasps.

Stridulating sounds.—Beetles, Waterboatmen, Moths, Ants, Locusts and Grasshoppers, Crickets, Cicada.

Sounds made by fishes.

Vocal cords and air.—(a) Frogs and Reptiles; (b) Birds (syrinx); (c) Mammals (larynx).

Reasons for sound producing.

The development of a language of words in man.

11TH MAY, 1942

A meeting was held in the Society's Room on this date. The President, His Excellency the Governor, presided.

The following were elected members of the Society:—Ordinary Members, Mrs. C. H. C. Hebblethwaite, Mr. C. H. C. Hebblethwaite; Associate Member, Mr. P. Crowcroft.

Mr. W. T. Dowsett delivered a lecture entitled 'Social Services and their importance in War-time and Post-war Period', of which the following is an abstract:—

1. *The Nature and Purpose of Social Services.*

To indicate the effects that a state of war may reasonably be expected to produce upon the social services, and to suggest any desirable developments in them after the war, the purpose of social services must be realised. Examination of the type of services given in such classifications as the Drage Return (1921) and the Political and Economic Planning Report (1937) indicates that their object is 'the enhancement of the personal welfare of individual citizens of the community'. History shows that the motives behind their inauguration all accepted the existing social and economic system without intention to change it. Furthermore, while in the nineteenth century the growth of the services was haphazard, in this generation the aims of consistent application and unified purpose are appearing.

Social services may thus be defined as that unified body of services, undertaken or supervised by the State, which accepts the existing social and economic system without seeking merely to preserve it or, alternatively, to change it, but which for motives of social or economic efficiency, endeavours to assure to each individual or family unit all those requirements of a reasonable living standard that the system may otherwise fail to provide. In a community with an arbitration system aiming to secure for each employed worker what is conventionally called a living wage, the following would be the chief fields of such social service structure:—(a) employment (including exchanges, re-training agencies, and employment insurance); (b) health (involving hospitals and public medical services, inspection and health insurance); (c) full education (including with schools and universities such institutions as playgrounds, museums and state theatres). (d) old-age and invalid pensions, provided as far as possible on the insurance principle

2. *Social Services in War-time.*

Since social services accept the system, their pattern must be changed to recognise the conditions of total war. Three conditions are involved:—since war means community sacrifice the general level of the services must fall; but, since the change in the economic pattern impinges disproportionately upon different groups, certain specific services will need actual extension; and some services may expand as part of the war organisation of the community.

Two factors will produce the changes:—increased man-power needs, and curtailed customer demand. The former will stimulate the employment function, developing new machinery for transfer across industries. It will expand physical education and vocational training, but depress other educational services generally. Other services will expand to meet the needs of dependents of men in the forces, but will otherwise tend to contract.

The curtailing of consumer demand will call for some extension of relief services, for the burden of the war will bring increasing numbers in low income groups nearer the breaking point. Moreover, food deficiency, overstrain, and the risk of epidemic will tend to extend the public health function.

3. *Social Services after the War.*

The post-war period will be concerned with the transfer of industry from war to peace, and industrial adjustment to the emerging new international trade conditions. Thus, while there will be a call to restore services contracted in war-time, the chief extensions will occur where increased employment is involved. Re-training agencies will be strengthened. Education should be extended to find new administrators, to meet possible enforced leisure, and to stimulate the movements towards more tertiary employment. New hospitals will provide employment for builders and doctors. Playgrounds, beside involving construction, will find openings for trained supervisors.

When a degree of equilibrium is reached, welfare should become the chief objective. This will necessitate an all-round extension of social services, but the most important problem will then be the devising of administrative machinery capable of producing the ideal unified body of services that we have failed so far to obtain. Since all these tasks are urgent, the great need is for immediate research and planning. The blue-prints should be ready before the war ends, for only immediate application can prevent disaster.

8TH JUNE, 1942

A meeting was held in the Society's Room on this date. The President, His Excellency the Governor, presided.

Mr. E. T. Emmett delivered an illustrated lecture entitled 'Frenchman's Cap', of which the following is an abstract:—

It is not known who named Frenchman's Cap. The mountain is mentioned by Jorgensen in his explorations of 1827, and the name appears on maps of 1830. Surveyor-General Sharland climbed portion of the mountain in 1832. The cairn was erected during Surveyor-General Sprent's surveys, about 1850. On a small piece of wood near the cairn are carved the names of Tully, Glover, and Spong, who ascended the Cap in 1859. A track was cut to the summit in 1910 by J. E. Philp by way of the Barron Pass, but this became overgrown. It has been re-opened, and this is the route now followed, starting by the Jane River track from the Hobart-Queenstown road, turning off at a point in the Loddon Plains, where Philp's direction board still remains. The distance is not much more than twelve miles from the Queenstown highway to the summit, but the country is extremely rough and it is a good two-day journey. The scenery is highly spectacular, with a sheer wall of white quartzite rising for nearly 1500 ft. from Lake Tahune. On the route are forests of extraordinary beauty. The lecturer suggested that it would be profitable after the War to have the track made easier and two or three camping huts provided, for the magnificence of the area would attract quite a large traffic. About 38 square miles round Frenchman's Cap has been proclaimed a National Park.

### 13TH JULY, 1942

A meeting was held in the Society's Room on this date. The President, His Excellency the Governor, presided.

The following were elected members of the Society:—Miss B. B. Adams, Mr. H. J. King, Mr. Roy Smith.

The Secretary announced that Mr. C. E. Radcliff had presented a copy of the two-volume work of Erasmus Darwin 'Zoonomia' to the Society's Library, and the books were laid on the table for the inspection of members.

Photographs of old Hobart were also displayed on the table. These were taken by Mr. W. H. Craig, Architect, of Melbourne.

Mr. G. P. Whitley, Ichthyologist of the Australian Museum, Sydney, delivered an illustrated lecture entitled 'Sharks', of which the following is an abstract:—

Mr. Whitley began by dispelling some popular delusions. Most sharks, far from being ferocious man-eaters, were harmless fish-eating animals. It was not necessary for them to turn over on their backs to take their food, neither did they always show the dorsal fin above water. Both white and coloured persons have been attacked by man-eaters. No authentic case of shark attack in Tasmanian waters was known to the lecturer.

Recently, a shark fishery had sprung into prominence in Victoria, where sharks were required for food and as a source of oil; they also yielded leather and fertilizer. The fishing methods and disposal of the catch were described. The need for biological research on sharks was stressed so that depletion of a valuable industry could be guarded against. Correct classification of the species was of prime importance, followed by a stabilising of the vernacular names. Investigations into the numbers and sizes of sharks caught, their growth, food, sex-ratio, and breeding habits were discussed. Sharks had recently been marked and liberated for the first time in Australia, in the d'Entrecasteaux Channel, by means of celluloid tags inserted in their bodies. It was hoped that the tags would be recovered by persons cleaning the sharks when recaptured and thus data on migration and growth would be secured.

### 24TH AUGUST, 1942

A meeting was held in the Society's Room on this date. Mr. Henry Allport, Vice-President, presided.

The Secretary intimated that, until further notice, the Library hours would be as follows:—

Mondays: 10 a.m. to 1 p.m. and 2 p.m. to 5 p.m.

Wednesdays and Fridays: 10 a.m. to 1 p.m.

Also at 7.30 to 8 p.m. on the evenings when a General Meeting is held.

The Secretary tabled a paper entitled 'The Phreatoicoidea', by Professor G. E. Nicholls, which had been submitted for publication in the Society's Journal. It was agreed to submit this to the Standing Committee.

Dr. J. B. G. Muir delivered an illustrated lecture entitled 'The present position in North China and Manchukuo'.

#### 21ST SEPTEMBER, 1942

A meeting was held in the Society's Room on this date. The President, His Excellency the Governor, presided.

The following were elected members of the Society:—Mrs. N. I. Stewart, Dr. E. T. J. Ick.

Dr. J. C. Jaeger delivered an illustrated lecture entitled 'Charcoal, its Properties and Production', of which the following is an abstract:—

A discussion of the properties of charcoal and of their effects on its performance in gas producers was given. In this work charcoal is regarded as being composed of volatile matter, ash, and carbon. The volatile matter consists of combustible gas, together with a small proportion of condensable vapour or tar. A high percentage of volatile matter is desirable, provided excess tar is not present, charcoal of over 25 per cent volatile content usually contains too high a concentration of tar, and that from partially carbonized wood almost certainly does so. Charcoal of high ash content also is undesirable, but no Tasmanian timbers have been found to give an abnormally high ash content. Bark, however, has a high ash content and thus must be removed before carbonizing.

The quality of charcoal is greatly influenced by the rate at which the wood is heated during the burning process; if the heating is rapid a friable, low volatile charcoal is produced, while slow heating gives a hard, high volatile charcoal. Large pieces of wood may heat rapidly in their interior because of the heat given out by the wood when carbonizing, and thus the charcoal from large pieces of wood may be inferior to that from small. Charcoal made from green wood has a flakey structure, except in the outer layers, due to the shrinking of the wood when drying.

The requirements of a satisfactory process of charcoal burning are firstly that there be an adequate control of the draught, and secondly that the draught should not pass through burnt charcoal. Charcoal is normally burnt in open or closed pits, or in kilns. The open pit method is not very satisfactory as there is little control over the draught and the burning is very hot, giving a light, soft, low volatile charcoal. The reverse draught closed pit has a simple but adequate draught control and should be capable of producing almost as good charcoal as steel kilns, in the latter very careful regulation of the draught is possible. The latest advance is the Kurth kiln which provides a continuous process, wood being fed in at the top and charcoal removed from the bottom, the recovery of valuable by-products is possible with this kiln.

#### 26TH OCTOBER, 1942

A meeting was held in the Society's Room on this date. Mr. Henry Allport, Vice-President, presided.

The following were elected members of the Society:—Mrs. O. Cornell, Mr. W. Baulch, Mr. E. A. Elms.

Mr. A. L. Meston delivered a lecture entitled 'Place Names in Tasmania'.

Miss Travers lent her copy of the illustrations to Péron's Voyages. This was laid on the table, and was examined by members after the meeting. These maps gave some of the old French names.

The following is an abstract of the lecture by Mr. Meston:—

Place names may be classified into three groups. First there are those given in honour of some person, place, or event; secondly those given to commemorate some incident; and thirdly those descriptive of the physical features they name.



Tasman's Frederick Henry Bay and Maria Island, Hayes' Ralph's Bay and the River Derwent, Flinders' Waterhouse Island, Point Hibbs, Mts. Zeehan and Heemskirk are examples of the first group; Storm Bay, Bay of Fires of the second group; and the great number of names bestowed along our northern coast by Flinders in 1798, such as Low Head, Round Hill, Table Cape, Rocky Cape, Circular Head, Cape Grim of the third group.

Many Tasmanian place names have wandered from their original location. Two prominent examples are Frederick Henry Bay, which by an error of Furneaux was transferred from a bay on the east coast to a bay near the mouth of the Derwent, and the Eldon Range, which has been applied to a range much farther to the south than that so designated by Hellyer in 1829.

Many place names on the coast of south-east Tasmania are the result of famous French expeditions, those of Bruni D'Entrecasteaux in 1792 and 1793 when Huon Kermandec was second in command, and that of Baudin in 1802.

Colonel Paterson named Launceston and the River Tamar in honour of Governor King who was born at Launceston, England, and the high mountain clearly visible from Launceston he, as a good Scot, named Ben Lomond.

To Governor Macquarie, who visited the island in 1811 and 1821, we owe names such as Lachlan, Macquarie, Elizabeth, Campbell, wherever found. The latter two in honour of his wife. To him, also, we owe the names Sorell, Perth, Oatlands, and Corra Lynn, to mention only a few. He also gave the appropriate name of Mt. Nelson to the marine signal station at Hobart. Governor Sorell who had served in the Peninsular War bestowed on the mountain which forms such a magnificent background for Hobart the name of Mt. Wellington.

Mt. Roland a prominent mountain in the north of the island affords an interesting example of the way a name is altered by the carelessness of mapmakers. In 1824 Captain Rolland an officer of the regiment stationed here determined to make his way from the coast near Port Sorell and ascend the mountain. After enduring hardships and encountering difficulties which nearly cost him his life, he was forced to return, defeated. From this circumstance the significant name Rolland's Repulse was bestowed. Under the misguided hands of cartographers, first the word Repulse was changed to mountain and later an 'l' was dropped.

Explorers, such as Kelly, Frankland, and Gould have given us many names. To Kelly we owe Port Davey, Sarah Island (in honour of Mrs. Birch, wife of Thomas Birch, merchant of Hobart, who backed Kelly), and the Gordon River (in honour of James Gordon, of Pittwater, who lent Kelly the whaleboat for his voyage). To Frankland the classic names of Olympus, Ida, Pelion, as well as Lake St. Clair, Manfred, Cuvier, Petrarch. To Gould Sedgwick, Lyell, Owen, Huxley, and Jukes.

Many of the names of the features of the N.W. Coast we owe to the V.D.L. Co.'s officers. Among them are Mersey, Forth, Emu, St. Valentine's Peak, Cradle Mt., and Barn Bluff.

In later years recourse has been had to native names, some of which are quite appropriate. Of these Conara (black), Emita (sand), Parattah (frost), Powranna (a snake), Waddamana (a large river) may be mentioned; but others such as Marrawah (one), Moorina (indolent), Narrawa (yes), Kaoota (dusk), Magra (a day) have no significance.

#### 25TH NOVEMBER, 1942

A meeting was held in the Society's Room on this date to celebrate the Tercentenary of the Discovery of Tasmania by Abel Janszoon Tasman. The President, His Excellency the Governor, presided.

The following papers were laid on the table, and taken as read:—

1. Early Town Planning in Hobart, by Dr. C. Craig.
2. On some new Hadrotarsidae (Araneae) with Notes on their Internal Anatomy, by Dr. V. V. Hickman.
3. Studies in Tasmanian Plants: I. Variation in *Pultenaea juniperina*, by Miss W. M. Curtis.

After introductory remarks by His Excellency, in which he drew attention to the importance of the occasion, Dr. W. L. Crowther gave an illustrated lecture on Abel Janszoon Tasman, of which the following is an abstract:—

In this address, the background to the life and exploits of Abel Janszoon Tasman was briefly reviewed and stress was laid on the important part played by the Spanish and Portuguese in the discovery and opening up of the new worlds of America and the East Indies and the steady rise of Holland as a great sea power.

Attention was called to the coincident unfolding of the great maritime development of England and its association with such navigators as Francis Drake in the America's and Middleton in the East Indies.

Here a fitting tribute was paid to the historical work done for this Society towards the end of last century by James Backhouse Walker: his most important contribution being a description of the career and discoveries of Tasman, especially in relation to Tasmania. This monograph with the great work of S. Heeres has been the source from which local historians have hitherto drawn. To illustrate this address, pictures of areas of the Tasmanian coast associated with Tasman's expedition were shown, as well as maps, etc.

In conclusion, it was stated that, owing to world conditions, it had not been practicable to systematically examine new material relating to Tasman's landfall, anchorage, and landings. Such sources included Huydecooper's Journal and his maps of Visscher, both that of Tasmania and his general map showing the day-by-day course of his ships. Gilsemans' map and R. Posthumus Meyo's work on Tasman and Visscher were also mentioned as throwing new light on Tasman's landfall and the watering place at Blackman's Bay.

Finally the decision of the Tasmanian Government to re-name Green Island 'Visscher's Island', was welcomed, and the hope expressed that, to celebrate the Centenary of the Royal Society, research on Tasman's discovery to be undertaken by a qualified historian.

Mr. W. H. Hudspeth read a note on a chart by Gilsemans, Supercargo and Draughtsman on the 'Zeehan', a copy of which has recently been acquired by the Mitchell Library, Sydney.

Dr. J. A. Boot, formerly Netherlands Consul in Tasmania, then gave an address dealing with the background of Tasman's early life and with his discoveries.

The following gentlemen gave short talks on the subject of Tasman's discovery of Tasmania:—Mr. H. Allport, Mr. A. L. Meston, Mr. W. N. Hurst, Mr. E. T. Emmett, and Mr. H. O'May.

Afterwards a conversazione was held in the Art Gallery, when coffee was served

## Northern Branch

### Annual Report, 1942

Meetings of the 1942 Session, other than the Annual Meeting and Public Lecture, were held in the Lecture Room at the Queen Victoria Museum and Art Gallery.

18TH MAY, 1942

#### *Annual Report and Public Lecture*

The Annual Meeting for 1942 was held in the class-room, Public Library, at 7.30 p.m.

Mr. F. Smithies presided. The following were elected officers for 1942:—

President: Mr. F. Smithies.

Council: Mr. F. Smithies (Chairman), Mr. F. Heyward, Mr. W. R. Rolph, Mr. V. D. Allen, Mr. G. McKinlay, Hon. Tasman Shields, Mr. J. R. Forward, Mr. J. E. Heritage, Dr. R. A. Scott.

Hon. Secretary: Mr. E. O. G. Scott.

Hon Auditor: Mr. J. R. Forward.

The Annual Report and the Statement of Accounts, which showed a credit balance of £31 18s. 10d., were read and adopted.

The Annual Meeting was followed, at 8 p.m., by a Public Lecture 'A Naturalist with a Cine-Colour Camera in Tasmania', by Mr. H. J. King. The lecture was given in the Public Library Hall, there being an attendance estimated at about two hundred and thirty.

The most important section of the films formed a continuation of the series of Nature-study films made by Mr. King in connexion with the educational programme of the Museum, and a series of bird studies was of particular interest. An interesting section of the film showed the development of the Common Fowl, and before this was screened the Honorary Secretary gave a short account of the various embryological phases of the Common Fowl, which he illustrated by means of a rough model in clay.

Mr. King alternated his series of natural history films with films of Tasmanian scenery.

#### 8TH JUNE, 1942

The President, Mr. F. Smithies, presided.

Mr. G. P. Whitley gave an illustrated lecture on 'Sharks' (see p. 166).

#### 20TH JULY, 1942

The President, Mr. F. Smithies, presided.

Dr. R. A. Scott, of the Department of Agriculture, gave a lecture on 'Tasmanian Potato Problems'.

Dr. Scott pointed out that, though to a layman the question of growing potatoes for food might seem a relatively simple problem, actually the subject is a very complex one, and problems raised in connexion with it involved several distinct departments of Science.

The speaker first discussed the problem of potato diseases. Different types of diseases were specified, and a distinction drawn between those more intimately involved with the organism, and those that were more or less incidental characteristics of the environment. This distinction led to a brief consideration of the modern Russian experiment of growing potatoes from seed.

The main part of Dr. Scott's address was devoted to a consideration of the problem of what constitutes quality in a potato, and to an account of methods adopted in an attempt to find measurable factors determining, wholly or largely, the apparent rather elusive characteristic of quality. A brief historical survey of work along these lines was given, with particular reference to the outstanding results of the Edinburgh School of Investigators.

Attention was called to the differing starch content of various varieties of potato, and to the character of the starch content curve, plotted against time, in the case of the individual tuber. This section of the address was illustrated by a practical demonstration of specific gravity, as used by Dr. Scott in his own researches.

The address was followed by a general discussion, in the course of which Dr. Scott, in answer to inquiries, gave some most interesting information.

31ST AUGUST, 1942

The President, Mr. F. Smithies, presided.

Mr. P. H. Bond gave a lecture on 'Synthetic Rubber'.

Mr. Bond commenced by stating that Natural Rubber was first obtained in the Americas, and was known as Para Rubber. It was a monopoly of American interests. Rubber seeds were then taken to the East Indies and Malaya, which became the chief rubber producing centres, but over-production resulted, and prices fell below economic level, however, after the last war prices were stabilised. There are other sources of natural rubber besides the rubber tree, for example, the Russian Dandelion, Morton Bay Fig (related to the rubber tree), and other starch-producing plants.

Synthetic rubber did not exist as such, being incapable of synthesis, so that a better name would be artificial rubber. There are three hundred and thirty-three processes for making rubber, but only three so far were successful for making large quantities, namely the Buna, Neoprene, and Butyl. During the present war, America has been producing practically the whole of the Allies' supply of artificial rubber.

The only way in which Tasmania could produce rubber would be by the Neoprene process; all the material required for such an industry is available locally and is plentiful.

Mr. Bond concluded his address by observing that the day will come when synthetic rubber would play a bigger part in industry, and after the war it would outdo natural rubber.

The lecture was followed by a discussion, in which several members participated.

#### COUNCIL MEETINGS

Council Meetings were held on the 24th April, 18th May, 26th June, and 7th September.



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